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THE LIGHTNING TORPEDO VESSEL.

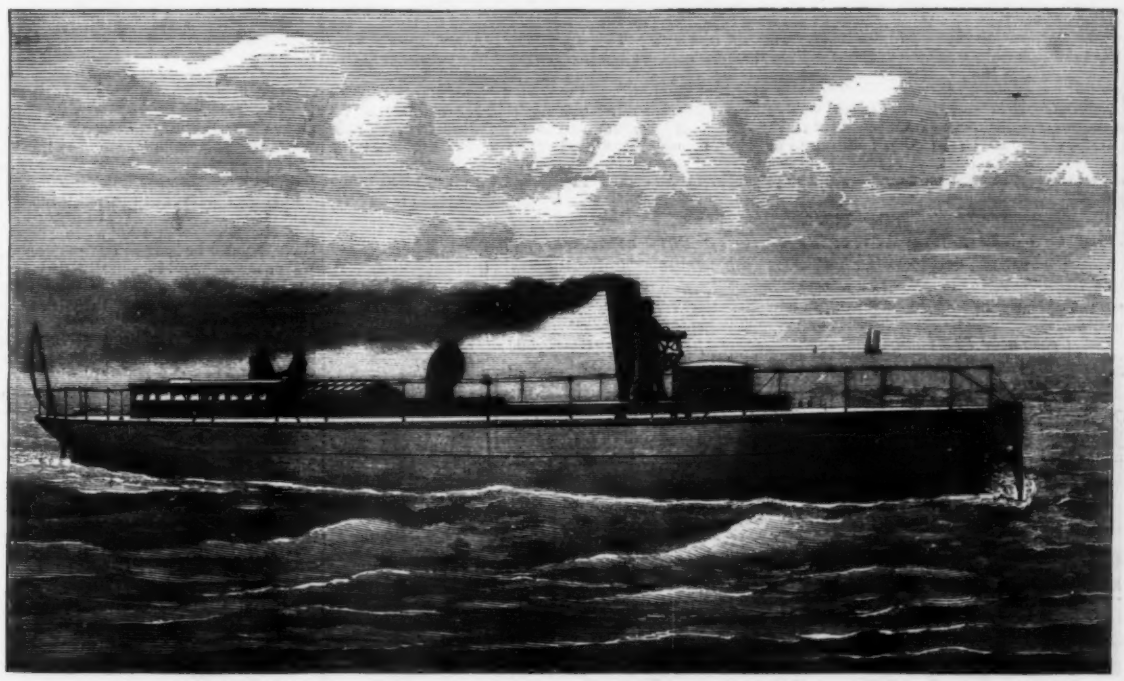
THIS vessel, of a new class, has been constructed by Messrs. Thorneycroft & Donaldson for the Lords of the Admiralty, and was lately inspected, at Westminster Bridge Pier, by a party of naval and military officers, members of Parliament (with the Speaker of the House of Commons), and other gentlemen, on the invitation of Mr. Ward Hunt, First Lord of the Admiralty. They went on board the vessel to test her speed, and ran down the Thames nearly as far as Long Reach, a distance of more than 22 miles, returning to Westminster within two hours and forty minutes of starting from there. The Lightning, indeed, although only 84 feet in length by 10 feet 10 inches beam, has the distinguished honor of being the fastest vessel in her Majesty's Navy, the mean speed attained on the preliminary runs being considerably over 19 knots per hour. It is proposed to arm the Lightning with the Whitehead torpedo; and from the recent debate in the House of Commons, when this subject was brought forward by Lord Charles Beresford, it would seem that the Whitehead torpedo almost threatens to change the character of naval warfare. This explosive instrument is 14 feet in length and 16 inches in diameter. It is made in three pieces—the head, which contains a bursting charge of 360 lbs. of gun-cotton; the balance chamber, which contains a contrivance for setting it so as to remain at any depth it is wished to travel under the water-line; and, lastly, the air-chamber, which contains the engines and the compressed air to drive them. Their length is 19 feet, and their diameter 18 inches, the appearance being exactly that of a cigar pointed at both ends. The head or foremost end contains the pistol or detonator which explodes the charge. The after end supports the screws—a right and left handed screw—which propels the torpedo, and are made of the finest steel. The air-chamber is tested to 1,200 lbs. on the square inch, but for the service it is only loaded to 800 lbs. The Whitehead torpedo can be made to go at the rate of 20 knots for 1,000 yards, and at any depth that is wished from 1 foot to 30 feet. It can be set to explode either on striking an object or at any particular distance under 1,000 yards. It can also be set so that if it misses the object aimed at, it would go to the bottom and explode on half cock or come to the top on half cock, so as to be recovered, as it has buoyancy enough just to float on the surface of the water when not in motion. It is fired by what is called an "impulse tube," which, out of a frame fitted to a port, discharges the torpedo into the water. It can be fired above the water, but will at once go to the depth it was set for, and straight to the object, no matter how fast the ship from which it is discharged is going, or how fast the object aimed at may be sailing or steaming. It is calculated to make a hole on bursting of 70 feet area, and there seems to be no doubt that if one of them hits a ship of any sort or description at present on the water, she must at once go to the bottom. The torpedo vessel need not be nearer than 1,000 yards, and, supposing that the first three shots did not take effect, she could still deliver more, as the vessel fired against would be positively unaware of the attack until she was blown up.—*London Illustrated News.*

A MR. PIGNELL has patented in England a plan for laying permanent way by placing felt between the rail and sleeper. It is claimed that this will reduce the wear of track and rolling stock, thus reducing cost and maintenance, while adding to the comfort of travel.

WAVE-MAKING RESISTANCE OF SHIPS.

By Mr. W. FROUDE.

AT the recent session of the Institute of Naval Architects, London, Mr. Froude said: The experiments which form the subject of the present paper are a part of the series of systematic experiments on the resistances of models which I have been conducting here. Their principal import, however, is to a great extent distinct from that of the rest of the series, and, as at the same time they throw valuable light upon the fundamental principles of resistance, I have thought it better to embody them at once in a separate report. The models used in the present experiments may be the best described as representing a series of imaginary ships of identical cross-section and identical form of end, the differences between them consisting in the length of parallel side, or uniform cross-section, inserted amidships. The lines of the longest ship of the series are shown in Fig. 1, the principal dimensions being as follows: Beam, 38·4 ft.; draught, 14·4 ft.; length of fore-body, 80 ft.; after-body, 80 ft.; parallel middle body, 340 ft.; total length, 500 ft. The other members of the series possess, of course, all the same dimensions, except the length of middle-body, which in the several cases is as follows: 340 ft., as above mentioned, 320 ft., 300 ft., 280 ft., 260 ft., 240 ft., 210 ft., 180 ft., 160 ft., 140 ft., 120 ft., 100 ft., 80 ft., 60 ft., 50 ft., 40 ft., 30 ft.; 20 ft., 10 ft., and 0· ft.; the total lengths of ship being consequently 500 ft., 480 ft., 460 ft.; 440 ft., 420 ft., 400 ft., 370 ft., 340 ft., 320 ft., 300 ft., 280 ft., 260 ft., 240 ft., 220 ft., 210 ft., 200 ft., 190 ft., 180 ft., 170 ft., and 160 ft. The models of the ships from 500 ft. to 280 ft. long inclusive were made to a scale of $\frac{1}{7\cdot5}$ full size, and those of the ships from 260 ft. to 160 ft. long were made to a scale of $\frac{1}{7\cdot6}$ full size. There is, of course, no special virtue in the absolute size of the ships the models are supposed to represent, nor in the absolute size of the models; the sizes adopted for the several models were those most convenient for construction and use, and the absolute sizes of the ships they are now taken to represent have been selected as being at the same time convenient multiples of the sizes of the models, and as being rational sizes for actual ships; and the results which I shall presently give for this series of ships have been calculated from those of the models in the usual manner. The models were tried stern first as well as head first. It is worthy of mention that the models of ships from 480 ft. to 280 ft. long inclusive, and which were $\frac{1}{7\cdot5}$ full size, were all made from that of the 500 ft. ship, by actually shortening it amidships—cutting out the necessary length of the middle body and rejoining the ends; and the models of the ships from 240 ft. to 160 ft. long, which were $\frac{1}{7\cdot6}$ full size, were made from that of the 280 ft. ship in the same manner. This was done partly for convenience and partly in order to insure identity in frictional quality of skin between the different members of the series. The resistance of the series of ships I have described, calculated on the assumption that the surface of the ships is equivalent in quality to a surface of fresh varnish or paint, are all given in Fig 3 in a manner which will be presently explained; but the resistances of a selection of these ships' heads are also given, in the more usual and more generally convenient form of curves of resistance—in Fig. 2—more than half of the series being left out to avoid overcrowding the diagram. The ship, whose curves of resistance are shown, range from 160 ft. to 480 ft. in total length, and consequently from zero to 320 ft. in length of straight side, by intervals of 40 ft. Their displacements range from 1,245 tons to 5,988 tons by intervals of about 568 tons. Comparing together the curves of resistance of these ships, we find that at the lower speeds every added 40 ft. of length, and 568 tons of displacement, increases the resistance by about the same amount; but at the higher speeds this harmony disappears. At 13 knots, for example, the 200 ft. ship makes considerably more resistance than the 240 ft. ship, which has 568 tons more displacement; and though at 14¼ knots the longer ship again makes the greater resistance, yet, even at 14 knots, the 280 ft. ship makes less resistance, both than the 200 ft. ship of 1,137 tons less displacement than the 240 ton ship of 568 tons less displacement; and at 14¼ knots the 200 ft. ship makes almost as much resistance as the 360 ft. ship of 2,275 tons more displacement. Similar anomalies appear in the comparison between other ships. The tendency to alternate excesses and defects of resistance in the shorter ship as compared with the longer appears throughout the diagram. Now, regarding the resistance of a ship as made up of three items, viz., skin friction, eddy-making resistance, and wave-making resistance, and remembering that the former is approximately proportional to the area of skin, so that an addition of successive equal increments of parallel side can only affect it to the extent of producing corresponding equal increments for every additional length, the anomalies that we have noticed can only be the result of some unexpected effect which the distance between the two ends produces upon the other two items which make up what may be conveniently termed the "residuary resistance." To analyze properly the nature of this effect, we must begin by eliminating the skin friction, the amount of which we believe we know by calculation. It also becomes our object to investigate, not so much the effect of speed upon the "residuary resistance" of a given form, as the effect produced on it by change of form at given speed; that change being the insertion of various lengths of straight middle body. Accordingly I have represented the results of all the series of ships both head first and stern first, in a special manner adapted to this purpose, and it will be seen that here the apparent anomalies explain themselves completely. In the curves shown in these figures the ordinates above the zero lines A A represent "residuary resistance," that is to say, total resistance minus the known resistance due to skin friction. The abscissæ represent, not speed, as in Fig. 2, but lengths of parallel side. Thus the ordinates to the spots on the vertical line B B are the "residuary resistances" of the 160 ft. ship having no parallel side, at the several speeds 6·75 knots, 9·31 knots, 11·23 knots, 12·51 knots, 13·15 knots, 13·79 knots, and 14·43 knots. The series of spots next to the left indicate the "residuary resistances" at the same speeds of the 270 ft. ship having 10 ft. parallel side, and so on, the distances to the left of the zero line B B, being length of parallel side on scale of 20 ft. to an inch. Through the series of spots representing the "residuary resistances" of the series of models at each speed curved lines are drawn, each of which represents the gradual change in "residuary resistance" corresponding to gradual elongation at a particular speed, the ordinate to any one of the curves at any intermediate point between the spots being the probable "residuary resistance" of the ship having length of parallel side represented by the corresponding abscissa, at the speed belonging to the curve. In the same manner the curves below the horizontal zero line A A represent



THE NEW BRITISH TORPEDO-STEAMER "LIGHTNING."

the change in the surface friction element due to elongation, the ordinates to these curves; measured downwards from the zero line A A, being, at the stated speeds, the skin friction resistance of the ships having length of parallel side corresponding to the abscissæ; so that measuring the total ordinate, from any of the spots representing "residuary resistance" of a certain ship at a certain speed, down to the surface friction curve for the same speed, will give the total resistance of that ship, and so supply, if necessary, the information omitted from Fig. 2. Setting the skin friction aside for the present, and considering the curve of "residuary resistance" only, we see that up to a speed of about 11 knots they are straight and level, showing that the residuary resistance is practically unchanged by insertion of parallel side; but that at higher speeds they present a series of regular undulations, showing that the gradual insertion of parallel side produces an alternate increase and diminution in the "residuary resistance." These undulations present the following characteristics; (1) The spacing, so to speak, or length of undulation, appears uniform throughout each curve. (2) The spacing is more open in the curves of higher speed, the lengths being apparently about proportional to the square of the speed. (3) The amplitudes, or heights of the undulations, are greater in the curves of higher speed. (4) The amplitude, in each curve, diminishes as the length of parallel side increases. Taking these graduated undulations in the diagrams of residuary resistance in terms of length of parallel sides as an experimental fact, their existence at once harmonizes the apparent anomalies in the comparison of the curves of resistance exhibited by Fig. 2. For instance, taking the case of the 200 ft. and the 240 ft. ships, at the lowest speeds, the "residuary resistance" being the same in both—the 240 ft. ship has simply an excess of resistance equal to its increase of skin friction. At the 13·15 knots speed, however, the position of the 200 ft. ship in the diagram falls near a summit, and that of the 240 ft. ship near the succeeding hollow, in the "residuary resistance" curve; and the consequent diminution in "residuary resistance" being greater than the increase of skin friction, the 240 ft. ship comes to have the least total resistance of the two. At the still higher speed of 14·43 knots the summit of the curve comes about half way between the positions of the two ships, so that the 240 ft. ship, having no diminution in residuary resistance to counterbalance the excess of skin, has again the greater total resistance of the two. Let us now examine the cause of these undulations. On Fig. 1, which shows the lines of the 500 ft. ship, is a diagram representing on the same longitudinal scale, but for greater distinctness, on a doubled vertical scale, the profile of the wave system, which as seen against the side of the ship, accompanies it at the speed of 14·43 knots. The profile was obtained by actual observations made when the model was running at the corresponding speed. This wave system consists of a series of crests at successive distances of about 125 ft., 235 ft., and 350 ft. from the bow; with troughs between them at distances of about 180 ft., 295 ft., and 410 ft. from the bow. Turning now to the diagram of "residuary resistance" at the same speed, we find that the successive hollows, or points of minimum resistance, correspond to total length of ship of about 168 ft., 277 ft., and 387 ft., and that the successive summits, or points of maximum resistance, correspond to total length of ship of 222 ft., 333 ft., and 446 ft. Now, if we deduct the figures just quoted as the several distances of the crests of the waves astern of the bow, from the lengths of ship given by the successive points of minimum resistance, we find that these ships have a wave-crest in each case about 40

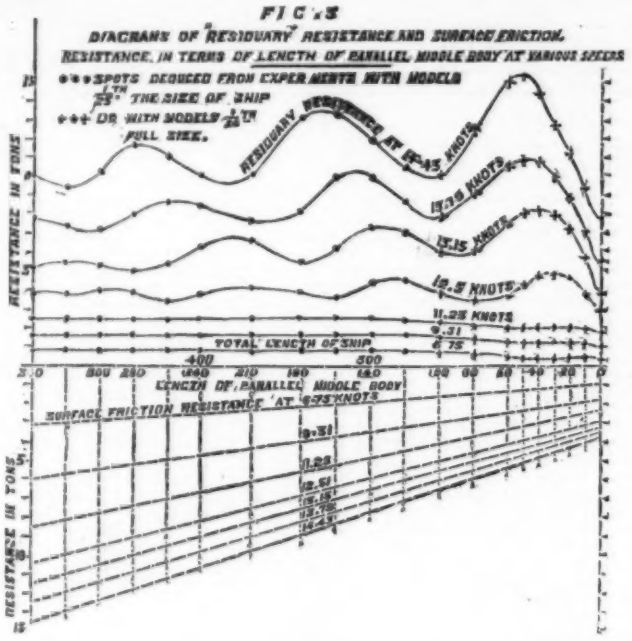
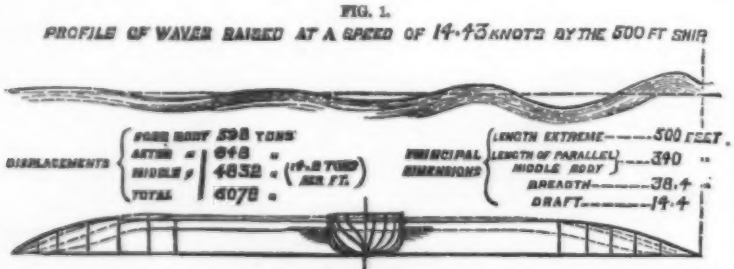


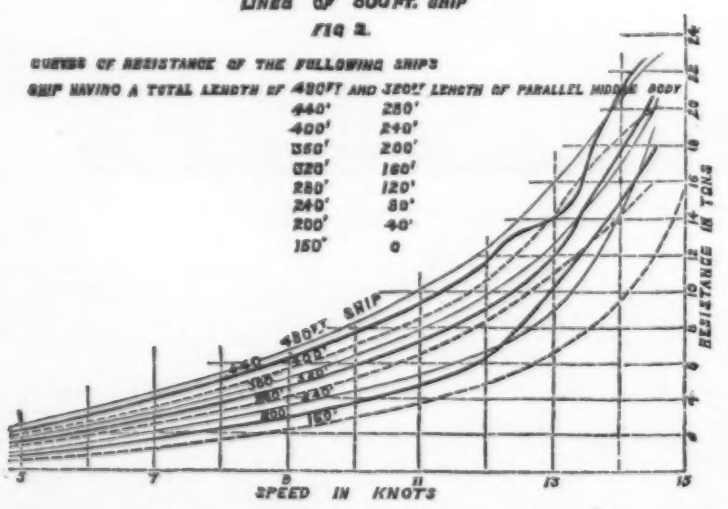
FIG. 1.

PROFILE OF WAVES RAISED AT A SPEED OF 14·43 KNOTS BY THE 500 FT SHIP

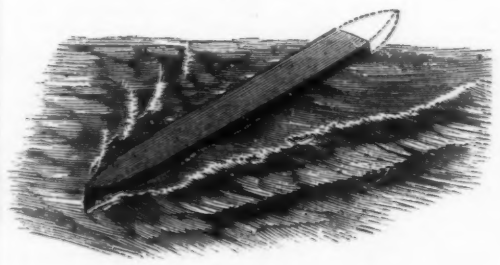


LINES OF 500 FT. SHIP

FIG 2.



ft. ahead of the stern post; and if we deduct the distances of the troughs of waves astern of bow from the lengths of the ships having maximum resistance, we find that these ships have a wave trough about 40 ft. ahead of the stern-post. This 40 ft. or so is half the length of the after body, so that the "residuary resistance" is smallest when the middle body is of such length as to place the middle point of the after body where a wave crest would be if the middle body were continued, and largest when of such length as to place it where a trough would be. The inference is obvious, that the undulations in the residuary resistance diagrams are due to the variations of quasi-hydrostatic pressure against the after body, corresponding with the variations in its position with reference to the phases of the train of waves, there being a comparative excess of pressure—causing a forward force or diminution of resistance—when the after body is opposite a crest, and the reverse when it is opposite a trough. This circumstance at once explains all the characteristics of the undulations of these diagrams which were noticed in (4). Their spacing is uniform at a uniform speed, because waves of given speed have always the same length; it is more open at the higher speeds, because waves are longer the higher their speed; their amplitude is greater at the higher speeds because the waves made by the ship are higher, and their amplitude diminishes with increased length of middle body, because the wave system, by diffusing itself transversely, loses its height. It seems, therefore, impossible to doubt that the variations in position of the after body, with reference to the wave system, is the sole cause of the variation in residuary resistance, represented by the undulations of the diagrams in Fig. 3, and which produces such great apparent anomalies in the comparison of the series of curves of total resistance shown in Fig. 2. This discovery is a most material addition to our conceptions of the manner of operation of wave-making resistance, and certainly serves to interpret many apparent anomalies in the curves of resistance of various forms. Hitherto our knowledge of the laws of wave-making resistance has amounted to little more than a crude appreciation of one broad principle, which underlies the most prominent manifestations of this kind of resistance, The principle is described in my lecture on "The Fundamental Principles of the Resistance of Ships," at the Royal Institution, in May, 1876, and I think I cannot do better than quote the description here: "The waves," generated by a ship in passing through the water, "originate in the local differences of pressure caused in the surrounding water by the vessel passing through it; let us suppose, then, that the features of a particular form are such that these differences of pressure tend to produce a variation in the water level shaped just like a natural wave, or like portions of a natural wave of a certain length. Now an ocean wave of a certain length has a certain appropriate speed, at which only it naturally travels, just as a pendulum of a certain length has a certain appropriate period to swing natural to it. And just as a small force recurring at intervals corresponding to the natural period of swing of a pendulum will sustain a very large oscillation, so when a ship is traveling at the speed naturally appropriate to the waves which its features tend to form, the stream line forces will sustain a very large wave. The result of this phenomenon is, that as a ship approaches this speed the waves become of exaggerated size, and run away with a proportionately exaggerated amount of power, causing corresponding resistance. This is the cause of that very disproportionate increase of resistance experienced with a small increase of speed when once a certain speed is reached, an instance of which is exhibited at a speed of about thirteen knots in the curves of resistance shown in Fig. 2. We thus see that the speed at which the rapid growth of resistance will commence is a speed somewhat less than that appropriate to the length of the wave which the ship tends to form. Now, the greater the length of the wave is, the higher is the speed appropriate to it: therefore, the greater the length of the waves which the ship tends to form, the higher will be the speed at which the wave-making resistance begins to become formidable. We may, therefore, accept it as an approximate principle, that the longer are the features of a ship which tend to make waves, the longer will be the waves which tend to be made, the higher will be the speed she will be able to go before she begins to experience great wave-making resistance, and the less will be her wave-making resistance at any given speed. This principle is the explanation of the extreme importance of having, at least, a certain length of form in a ship intended to attain a certain speed: for it is necessary, in order to avoid great wave-making resistance, that the 'wave features,' as we may term them, should be long in comparison with the length of the wave, which would naturally travel at the speed intended for the ship." This view of the matter, then, recognizes the tendency of a ship, when the speed bears a certain relation to the length of her wave-making features, to make large waves, and to incur corresponding wave-making resistance. But it does not take account of the possibility of the waves made by one feature of the form so placing themselves with reference to other features as by the differences of pressure essential to their existence, either to cause an additional resistance, or, on



the other hand, to cause a forward force, which partly counterbalances the resistance originally due to their creation. The way in which this may occur we have seen strikingly exhibited in the results of the experiments I have been describing. We see that in the very long parallel-sided form the sternmost of the train of waves left by the bow has become so small that its effect on the stern is almost insensible; and here we find, consequently, the united resistance due simply to the generation of a separate wave system by each end of the ship. As we gradually reduce the length of middle body; the stern is brought within the reach of waves large enough to produce a sensible effect, and according as it is brought into conjunction with a crest or a hollow the total wave-making resistance becomes alternately less or greater than that due to the sum of the actions of the two ends of the ship when acting independently; the wave-making resistance becoming least of all, except at the very highest speed, when the middle body is reduced to nothing. This alternately favoring and resisting action of the train of waves also serves to explain one somewhat perplexing phenomenon which has manifested itself in the curves of resistance of many models of actual ships which I have tried, namely, the appearance in them of humps or contrary flexures. We have seen that the resistance depends on the relative placing of the after body and the wave system; now the length spacing of the wave system, and, consequently, the positions of the trough and crests, depends on the speed, and therefore the position of after body, which is specially favorable at some given speed, may be specially unfavorable at a higher speed, and at a higher speed still may be favorable again. This may be seen by Fig. 3 to be the case, for example, with the 400 ft. ship.

The result of this alternation must be that comparing the curve of residuary resistance of, say the particular ship we are considering, with the mean of the curves of residuary resistance of the whole series of ships, the curve of the particular ship will, at moderate speed, be below the mean curve—will, at a higher speed, rise much above it—and at a still higher speed will sink below it again; and if the mean curve be, as is probable, a fair curve, the ship's curve will necessarily present a hump in the middle. Such humps may be seen in several of the curves shown in Fig. 2, and these, on analysis, clearly arise from the cause I have been considering. Although ordinary ships do not often exhibit a so markedly straight side as the series of forms we have been dealing with, nevertheless they frequently partake of this character quite sufficiently to introduce the operation of the causes we have considering. Whatever the form of entrance, it must tend to make a considerable train of waves as the speed appropriate to its length approaches, and whether the side be absolutely straight or gently rounded, the position of the run with reference to this train of waves will influence the resistance.

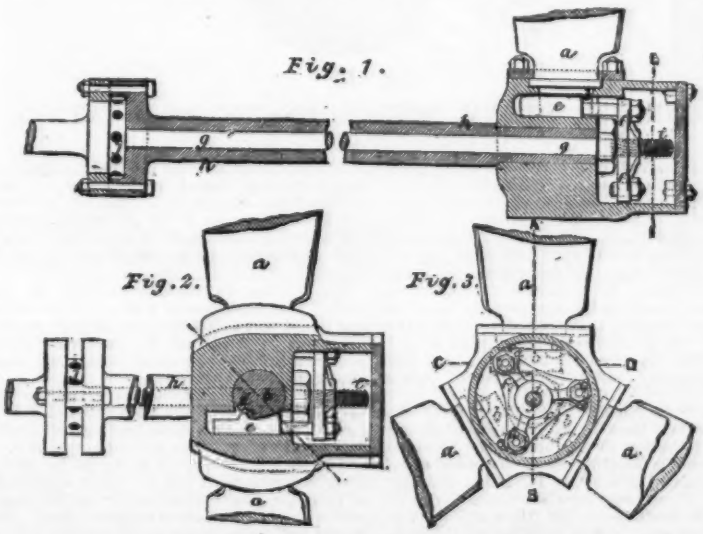
Thus, I think it quite certain that the two principal phenomena we have been examining—namely, the tendency to formation of a large train of waves at the speeds nearly appropriate to the length of the wave-making features, and the beneficial or prejudicial effect of the position of the after body with reference to this train of waves, must form conspicuous elements in the curves of resistance of all forms at relatively high speeds. But the results of the present experiments point out, and to some extent evaluate, another important element of wave-making resistance besides those we have considered. I refer to the series of waves which diverge from the bow, the maintenance of which must, of course, involve resistance. None of these waves, excepting the first, impinge on the side of the vessel at all, and consequently the resistance due to them, unlike that due to the series of transverse waves, will be precisely the same whatever the position of the after body. Now, we find that at the lower speeds the "residuary resistance" is unaffected by length of parallel side. It cannot, therefore, be due to the formation of transverse waves, and the natural inference is that it is due to the formation of diverging waves. A corroboration of this inference is the fact that the diverging series of waves, though at high speeds small in comparison with the transverse series, becomes of great comparative importance as the speed diminishes, and is perfectly visible at speeds at which the transverse series is imperceptible. Again, this lower speed "residuary resistance," which is unaffected by length of parallel side, and which I consequently attribute to diverging waves, is markedly greater in the case of the stern-first series of forms; this accords with the fact that the diverging waves of the stern-first series were visibly larger. At the same time, in attempting to estimate the exact amount of resistance due to the diverging waves, it must not be forgotten that some portion, at least, of the "residuary resistance" may be due to eddy-making, although this must be comparatively small in a form of such fairly sharp lines, with stern and sternpost both finished off to a knife edge. It seems probable that in other cases, as in this series, diverging waves are formed at speeds too low to produce transverse waves of importance, and that resistance due to the latter does not come into play until the speed of wave appropriate to the waves' features of the ship is nearly approached, when it begins to increase very rapidly. Consequently there may be a large class of cases where the speed is high enough to produce wave-making resistance due to diverging waves, but not that due to transverse waves; and where, therefore, the length of straight middle body, or its equivalent, would not have much effect upon the "residuary resistance." Such ships, however, as the Devastation, Fury, and Inflexible, certainly produce very marked transverse waves at full speed, and the phenomenon of the impact of the train of transverse waves upon the stern must doubtless constitute an important factor in the resistances of such ships.

Besides the conclusions of immediate practical importance which must inevitably spring from the series of experiments I have described in this report, I believe that a careful study of their results, in combination with our existing knowledge of the principles of wave motion, will ultimately throw most valuable light upon the details of operation on which wave-making resistance depends, and thus enable us to shape our experimental data concerning this element of resistance in a less empirical and more really instructive form.—*Engineer.*

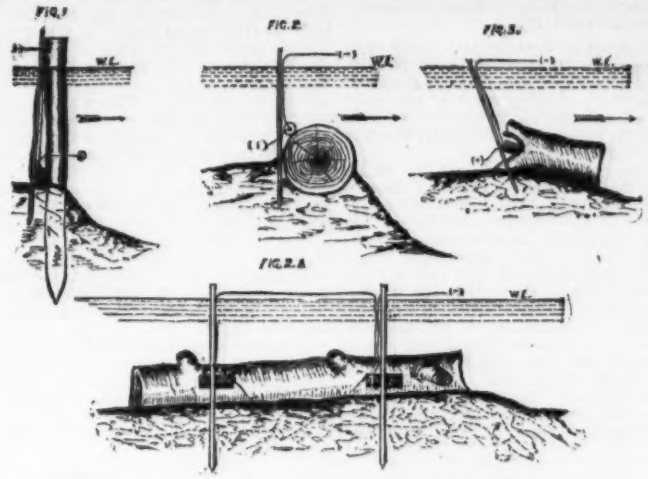
EYRE'S SCREW PROPELLER.

WE annex engravings showing a neat form of feathering screw propeller, designed by Mr. H. S. Eyre, of London, our illustrations representing the arrangement as applied to a three-bladed screw. Fig. 1 is a longitudinal vertical section (taken in the line A B of Fig. 3); Fig. 2 is a sectional plan of the same taken in the line C D of Fig. 3; Fig. 3 is a transverse vertical section taken in the line E F of Fig. 1. In these views *a a a* are the blades; *b b b* their roots, each having formed in it a recess *e*, at each side of which there is a flat part or plane *d*; *c* are racks or sliding plates, one in gear with each blade root; *f* is a crosshead or plate connected to each of the racks or sliding pieces *c* by nuts, as shown; *g* is the shaft for giving the necessary motion to the racks and crossheads for simultaneously altering the blades. This shaft passes through the hollow part of the propeller shaft *h*, and has formed upon a portion of its length a screw *i* passing through a correspondingly screwed hole in the crosshead or plate *f*, so that when the shaft *g* is turned its screw will cause the crosshead and the racks to be moved backward or forward, according to the direction in which the shaft is turned; *j* is a disk formed on the inner end of the shaft *g*; this disk, which prevents any end movement of the shaft, having holes formed in its periphery to receive the end of a bar or other instrument for turning the shaft *g*.

In the arrangement shown by the engravings the connection between the hollow shaft *h* and the main screw shaft is rather weak, but this is a detail which can readily be set right. It will be understood that by turning the shaft *g* within the shaft *h* the racks *c* are moved inwards or outwards according to the direction of the motion, and the blades of the propeller thus turned through the desired angle. At each end of the traverses of the racks the screw blades are locked by the flat planes formed on their roots taking a bearing in the corresponding planes on the racks, a very solid stop being thus formed. Altogether the arrangement has many good points and we hope to see it tested in practice.—*Engineering.*



EYRE'S SCREW PROPELLER.



BLASTING UNDER WATER WITH DYNAMITE.

SUBMARINE BLASTING.

ALTHOUGH subaqueous blasting with dynamite is by no means a novelty, its application without the usual contingent, boring, as applied lately to the removal of piles in the Danube River and of sunken trees in the Danube Canal, illustrates a simple and expeditious mode of getting rid of such obstacles in swift running streams at a minimum of expense.

The first obstacles to be removed were two piles, each 12 inches in diameter, about 16 feet apart, some 470 feet from the shore, and 100 feet below the States railway bridge over the river at Stadlaw, in the neighborhood of Vienna. The scour produced by the obstructions was, in the case of the upper pile, 4 feet, and of the latter 3 feet 3 inches; and as every effort to draw them had failed, blasting was adopted as a last resource. As seen from Fig. 1, an iron-shod stake was driven into the bed of the river above the piles in a slanting direction from their heads, leaving sufficient space for the insertion of the charge between the stake and the pile, and allowing the head of the former to be firmly attached to the latter. The charges adopted were for each pile 2¼ lbs. of dynamite in a tin case made water-tight with gutta-percha, and fitted with a gun-cotton cartridge and an electrical fuse passing along the stake. The positive current was very short, because a short piece of bare copper wire was allowed to project from the charge into the water, as shown, and the positive pole of the battery communicated with the water also. After the charges had been lowered by means of the stake, so as to be forced by the current against the foot of the piles, they were fired from the shore. The explosion, although it threw the water to a height of 16 or 17 feet, was attended with little detonation, effectually, however, removing the piles, which were broken short off at the ground level and carried away by the stream.

The second obstacle was an oak stem 16 feet 6 inches long and 5 feet 7 inches diameter, lying athwart the canal at right angles to the stream, with its roots deeply imbedded in the ground, and half buried in the gravel on the upstream side. Its position will be seen from Figs. 2 and 2*a*, as well as the depth of scour on the lower side.

Two charges each of 13¼ lbs. of dynamite No. 1, with gun-cotton cartridges and electrical fuses, were placed against the stem on the upstream side parallel to its center, and fastened by means of two iron-shod stakes driven into the ground. The application of the battery was the same as above; the explosions, which were, of course, simultaneous, were accompanied by a dull detonation, but the water, mixed with sand, mud, and splinters, was thrown to a height of over 30 feet. Several large pieces of the stem rose for a second or two, and then sank into the scour. Soundings taken shortly afterwards showed that the tree had been entirely destroyed, that the current had leveled off the previous silt with the scour, and that the canal bed had obtained its normal level.

The third obstacle was an oak stem, 6 feet 10½ inches long, and 3 feet 6 inches diameter, lying in mid-stream parallel to the flow. A charge of 9½ lbs. of dynamite No. 1 was laid as before between the roots, as shown in Fig. 3. The detonation was loud, and the water thrown to a height of nearly 40 feet. The stem was entirely destroyed and immediately washed away. The time occupied in removing the two stems, which were about a mile apart, was only three and a half hours, and the expenditure comparatively very small.

The reason for laying the charges free was that the current was so strong at the several points that an expensive arrangement would have been necessary to enable the stems to be bored, and the time required for boring would have been considerable, as the long stem would have required six; even then it is doubtful if the roots would have been entirely torn out. Possibly they might have remained a lesser but more dangerous hinderance to the traffic than the stems themselves, whereas the free charges produced sufficient shock on the whole body of the tree to utilize it as a lever in drawing the roots from the loosened earth.—*Engineer.*

EXTRAORDINARY STEEL-RAIL PRODUCT.

RECENTLY the steel-rail mill of the Lackawanna Iron and Coal Company, in the usual eleven turns, on a fifty pound rail thirty feet long, did in one week the following work, which is considered one of the most extraordinary on record: "Total number rails rolled, 6,173; average per turn, 561; total tonnage during week, 1,977.18; average time rolling each bar during entire week, including all stops during and between turns, 77 seconds; best single-turn rails, 740; best double-turn rails, 1,414; actual rolling time of above, consecutive, 1,414 bars, 23 hours 43 seconds—average 60¾ seconds per bar; 1,414 bars equal 4 miles and 90 feet of track. Greatest speed accomplished, 109 bars in 97 minutes, a little less than 53½ seconds per bar; 6,173 rails will lay 17 miles 2,895 feet of track." On the above figures the officers and men of the mill make the following claims and challenge comparison: 1. To have rolled the largest number of rails yet rolled in the world on one rail train in one week. 2. To have made the largest tonnage ever made on equally light rail in one week. 3. To have rolled the largest number of rails yet rolled in twelve hours. 4. The same claim as to twenty-four hours. Taking the above as an average, the company, using both its mills, could roll rails for a double track to Pittsburgh, a distance of four hundred and eighty miles, in twenty-seven weeks. This enormous amount of work turned out at No. 2 mill seems all the more when we compare it with that done at No. 1 mill on iron, now having the same capacity as No. 2, when the first Delaware, Lackawanna and Western track was being laid. The distance from Scranton to Great Bend is fifty-two miles, and it took the mill already mentioned nearly six months to roll the rails necessary, which could now be supplied in three weeks.—*Scranton Republican.*

TESTING STEEL-IRON WELDS.

IN a late issue of the *Railroad Gazette*, J. K. Sax gives the method which he employs to detect a perfect weld between the iron and steel in his car wheels: "We know in every instance before the wheel is sent out whether we have a perfect weld or not, simply by turning the edge of the thread of the wheel, which is now done in all cases. Therefore if the weld is perfect, when the tool reaches the junction or union of iron or steel, the turnings even on the extreme edge of the wheel, as they leave the tools, being part steel and part cast iron, in a perfect weld will stick firmly together and be inseparable, even though they may be not more than a 64th part of an inch in thickness. On the other hand, if there is not a perfect weld, the iron will invariably be separated from the steel in the turnings as they leave the turning tool, thus making a sure means of detecting any imperfections in the weld. So finding a perfect weld on the outer edge of the thread is a sure indication of a perfect weld in the center of the thread of the wheel."

TEST BOILER, MANCHESTER STEAM USERS' ASSOCIATION.

THE object was to construct an experimental boiler to be tested by hydraulic pressure up to the bursting point. Its desirability appeared evident to the Committee of the Association, especially with regard to the weakening effect of the openings cut for manholes, steam necks, etc., which it was firmly believed tended more to the rupture of boiler shells than was usually admitted.

The consideration of several instances of explosion which had been attributed by the Association's chief engineer to such necks, and to large openings not sufficiently strengthened, led the Committee to the determination to try the matter fully. Indeed, so completely were they alive to the weakness resulting from the large holes at the base of steam domes, and the presence of domes at all, that they had for years urged members when laying down new boilers to dispense with domes altogether. It was therefore arranged that a proper boiler should be constructed, of the diameter adopted in daily practice, and of the usual thickness of plates, with actual manhole, mouthpiece, etc., such as are common, so that the ultimate test should be decisive.

With this object then in view, they had a boiler constructed 21 ft. long by 7 ft. in diameter inside the inner plate of shell; with two furnace tubes 2 ft. 9 in. inside diameter with flanged seams, each ring being welded up solid, so that there would be no rivets or lap joint in the flue. The shell plates were $\frac{7}{16}$ in. thick, the ends welded up solid were $\frac{1}{2}$ in. thick, and the furnace tubes of $\frac{5}{16}$ in. plate; the material throughout being of the best Snedshill iron. All longitudinal joints were double-riveted, and circumferential ones single-riveted.

We give engravings (Figs. 1, 2, and 3) of this boiler showing the longitudinal section and two transverse sections, in which the arrangements of the joints, stays, gussets, rivets, angle-irons, and attachments are clearly shown. Fig. 4 shows pitch and arrangement of rivets, while Fig. 5 is a full size view of the rivets used. The holes were punched.

In the first experiment that was made, the boiler was complete as shown in Figs. 1, 2, and 3. The manhole mouthpiece on second plate from back end was of wrought iron, such as recommended by the Association. The cast iron pipe or seating for the blow-off elbow pipe to attach to, was also as is usual, while the gusset stays and longitudinal stays were the full complement provided for such a boiler for 75 lbs. working pressure. The front end manhole casting was placed on the inside of the front plate, and furnished with internal door and usual crossbar fixings. The wrought iron neck shown on the top of boiler and on the central plate was the special object of this first experiment, and it is more clearly shown in Fig. 6, in which all the dimensions are fully given. Fig. 7 is a sectional plan of this neck, and Fig. 8 shows, as does also Fig. 7, the lines where fracture ultimately took place. Before pressing the boiler up to the bursting point, careful records were taken as to the behavior of the boiler at all points, as the pressure gradually rose. The flat ends were carefully gauged to ascertain at what extent they gave way, and if any permanent "set" remained on withdrawal of pressure. The furnace flues were carefully gauged; the length of the boiler shell measured by rods fixed at one end and free at the other end, and having pointers at several places, and the circumference was also measured by two encircling steel bands passed round the boiler and weighted at each end, so that by horizontal lines drawn across them the least enlargement could be rendered clearly visible; some of these measuring preparations are shown in Fig. 9.

Up to the pressure at which the wrought iron neck (Fig. 6) gave way, viz., at 250 lbs. on the square inch, there was no movement of the ends beyond a slight permanent "set," which has remained the same throughout the whole of the tests, even after the removal of the two longitudinal stays, by which fact it is clearly shown that the arrangement of gusset stays here used is sufficient to secure the ends up to and beyond the limit of the strength of the shell.

The first rupture took place at the base of the 14 in. neck, and is shown in Figs. 7 and 8. Of course these fractures are in themselves, as here shown, only the commencement of the work of destruction, but it is self-evident to any one understanding the subject, that had the volume of water, which was supplied at 250 lbs., been greater, the rent would have extended instantly, and had steam pressure been the agent used instead of water, then complete destruction must have followed, by the development of rents in various directions, and with the usual accompaniments of loud report, damage to property, and probable loss of human life.

The boiler having been repaired by the attachment of a strong circular plate where the neck had been placed, as may be seen in Fig. 9 on the top of the boiler, was furnished with a cast iron manhole mouthpiece of the usual form. This casting was circular and was 16¾ in. inside diameter, and is shown in Fig. 10, and may here be compared with the wrought iron manhole mouthpiece, Fig. 11, which is 17 in. internal diameter, and upon a hole in boiler shell 18¼ in. diameter. It will be seen that the cast iron manway is 16¾ in. diameter inside, but requires a larger hole in boiler shell, viz., 20 in. diameter, to bring the edge of the shell plate to its proper distance from the centers of the rivets. The casting, which was of strong and substantial pattern, and quite sound throughout, gave way at a pressure of 200 lbs. per square inch, a large part of it flying off with considerable force, and so much more violent was the rupture than had been the case in the instance of the wrought iron neck at 250 lbs., that the shell plate was torn completely through on each side of the manhole, the rents being longitudinal until diverted by the resistance offered by the two ring seams through which they forced their way, and thence they began to pass circumferentially through the neighboring plates. Here again are clear lines of commencing rents whose ultimate development it is self-evident must have been utter destruction. The fractured portions of this casting are shown in Fig. 9, as is also the first wrought iron neck with its fractured flange.

At the next or third experiment, a steam dome 3 ft. in diameter was applied, only a small portion of the boiler shell having been cut away, but the strain at the base of the dome was such that violent leakage ensued, so that no more than 235 lbs. pressure could be maintained with the pumping power at command. A second trial was made with this dome, when it had been re-riveted with stouter rivet heads, suited to resist more satisfactorily the strong upward strain that was produced by the internal pressure, and in this case rupture was produced by the tearing of the bottom flange of the dome on the center line of the boiler at a pressure of 260 lbs. Up to this period the gauging of the flues and ends had been carefully noted, but no signs of distress were discovered, nor had any strain of the flat ends taken place.

The fifth test was made to ascertain the value of a single riveted joint as compared with a double riveted one, and it was found that at 250 lbs. the leakage at the single riveted joint was so great that the pumps were overpowered, and no increase of pressure could be obtained; the double riveted joint remained quite tight.

The sixth test was made to ascertain the value of an ordinary unguarded manhole with internal door and crossbars, such as have been in time past so very generally used, and are indeed but too often met with even now. The oval hole cut in shell measured 17 in. by 13 in., and in this case it must be remembered that the whole apparatus was *new* and of first-rate construction so far as the imperfect system of such a manhole and cover could be good. The inner cover lapped well to the boiler shell, and the joint having ample surface was made with new sheet india rubber. The crossbars

Fig. 1.

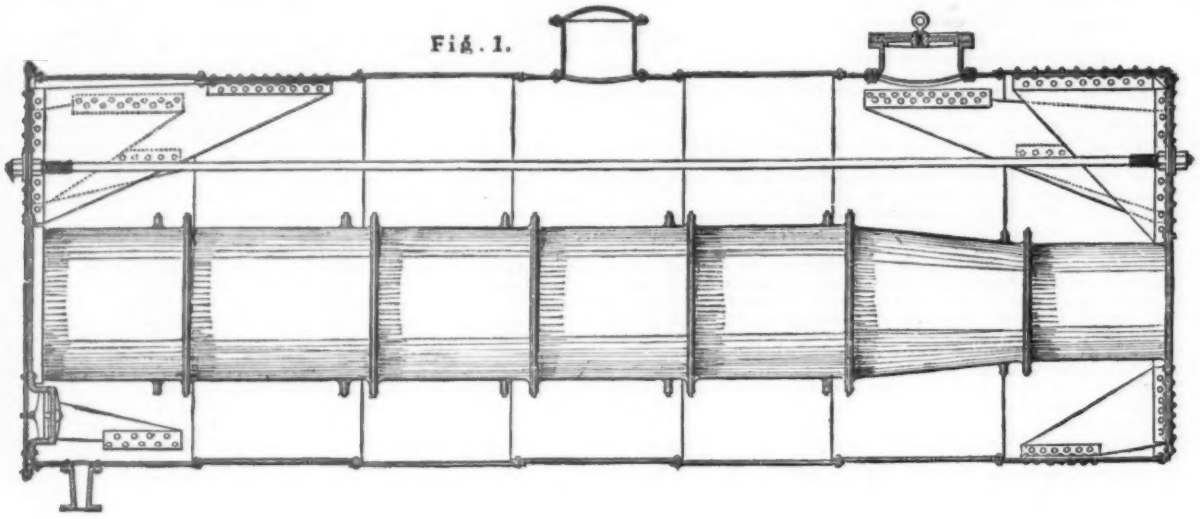


Fig. 2

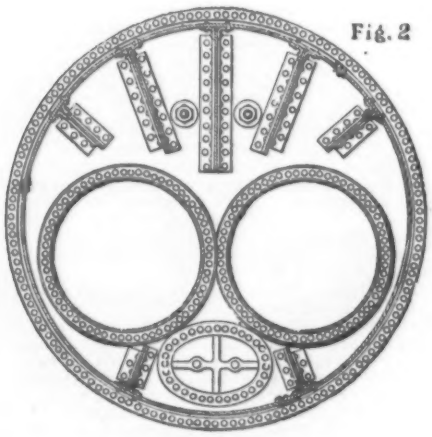
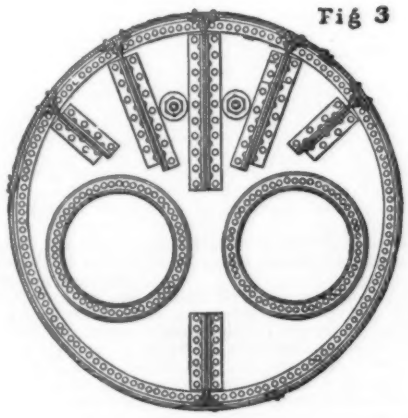


Fig 3



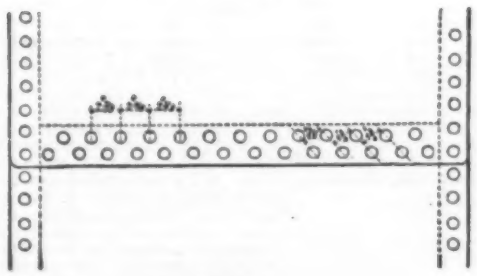


FIG. 4.

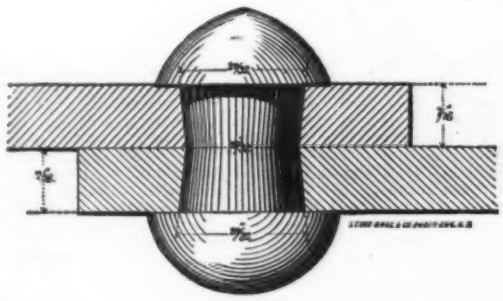


FIG. 5.

EXPERIMENTAL TEST BOILER.—MANCHESTER STEAM BOILER USER'S ASSOCIATION.

were of the proper length, so that their feet rested upon the shell plate, not beyond the limit of the cover below, but immediately over the lap, and thus the chances of the door were far above the average rate of strength. There was of course no loss of strength from repeated renewal of such a joint or from corrosion, but the door blew out, as is shown in Fig. 12, at a pressure of 200 lbs. per square inch, a longitudinal rent starting from one end of the manhole and running across the plate, and then extending some distance along the ring seam of rivets, and fracturing the next plate through a rivet hole.

Test number seven was a repetition of number five, to try if a *rent* instead or a simple leakage could be produced with a greater amount of pumping power, the idea having arisen that perhaps a single riveted joint might be taken as a sort of safety valve through which sufficient leakage and relief from pressure might ensue in case of overpressure, and

Double riveted work executed by hand was then compared with machine work, with a result similar to the last, in so far as this rent was very decisive and complete; the hand-worked seam giving way at 300 lbs. pressure, while the machine work remained good.

Previously to this there had been some intervening test regarding the stays, after which the longitudinal stay bolts were removed altogether, and the boiler was tested without them from that time to the end of the trials, so far as they have been carried, and no yielding of the ends has yet occurred.

Before reaching the highest resistance of which the boiler was reckoned capable, another illustration was afforded as to the risk of placing reliance on cast iron seatings for fittings to steam boilers. When the boiler had been once again restored with all joints double riveted by machine, and everything as good as could be, considering the many tests the

must be discarded, the final burst was attempted, and successfully carried out, when at 310 lbs. pressure a clear longitudinal rent was caused in the central ring of plates, and at the bottom of the boiler, just at the very spot that by all calculation should have been the weakest. Possibly, had the whole boiler been quite new when this last test was applied, and the iron not been subjected to repeated strains closely approaching its limit of strength, the pressure would have reached 320 lbs., or the ultimate calculated strength of the double riveted joint. Be this as it may, it has now been demonstrated that this form of Lancashire boiler, fairly made, and of good material, is reliable to the extent that calculation would lead one to expect.—*Engineering.*

THE Pacific Iron Works, San Francisco, employ from 300 to 400 hands, and produce castings, machinery, boilers, etc., to the value of nearly a million dollars annually. This

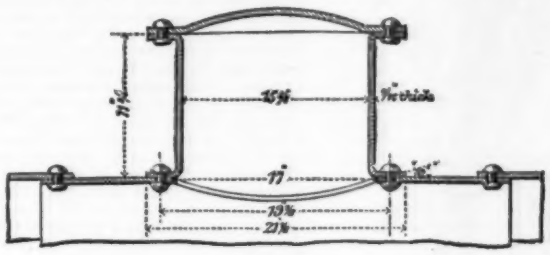


FIG. 6.

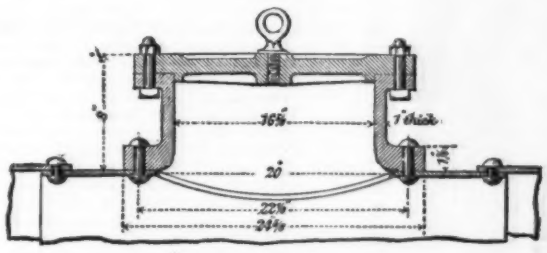


FIG. 10.

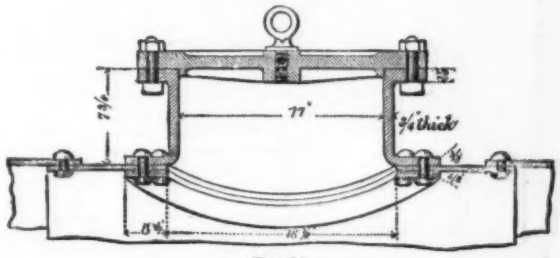


FIG. 11.

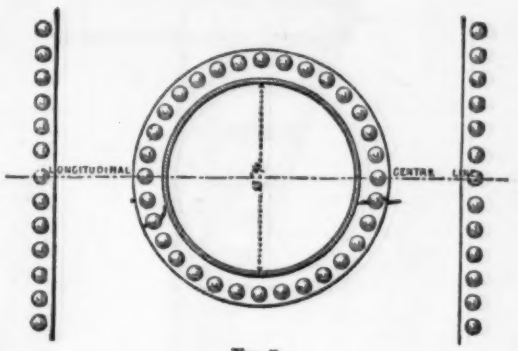


FIG. 7.

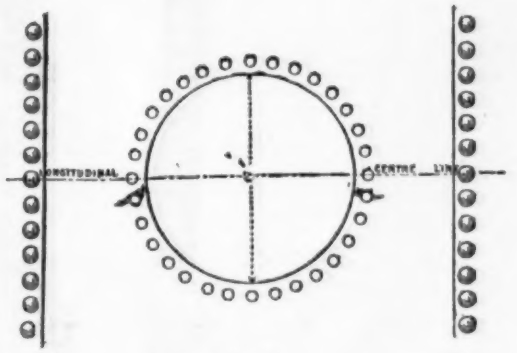


FIG. 8.

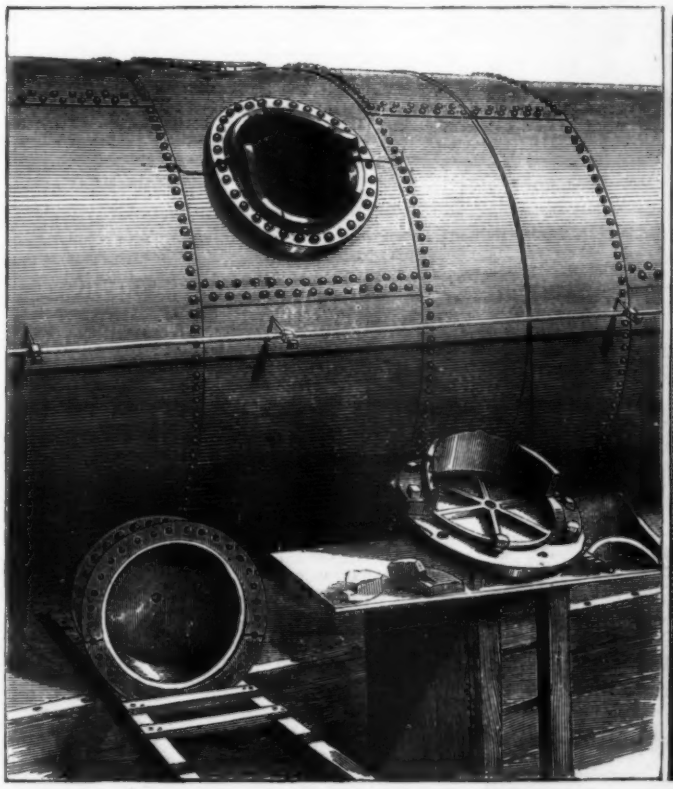


FIG. 9.

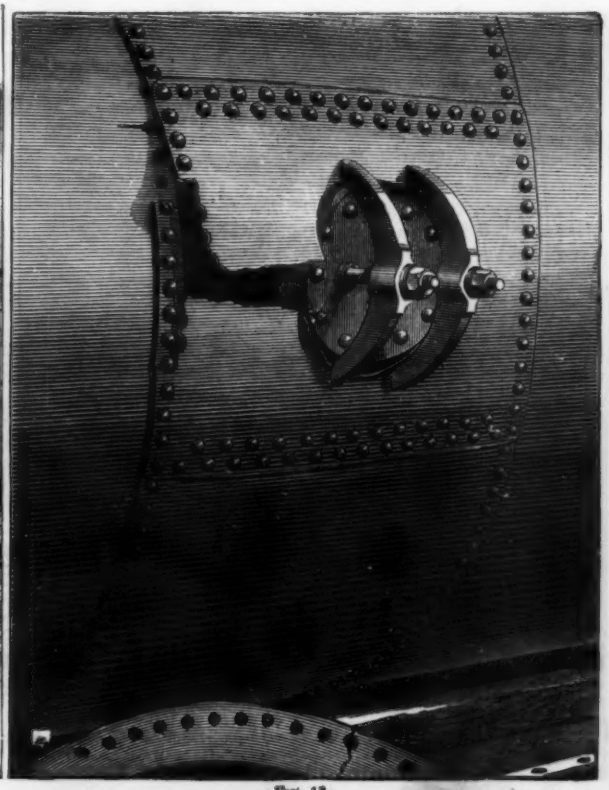


FIG. 12.

EXPERIMENTAL TEST BOILER.—MANCHESTER STEAM BOILER USER'S ASSOCIATION.

thus lead to the prevention of actual explosion. Such a theory, if not disproved, might have a very dangerous tendency, and the necessity of complete assurance was felt to be absolute.

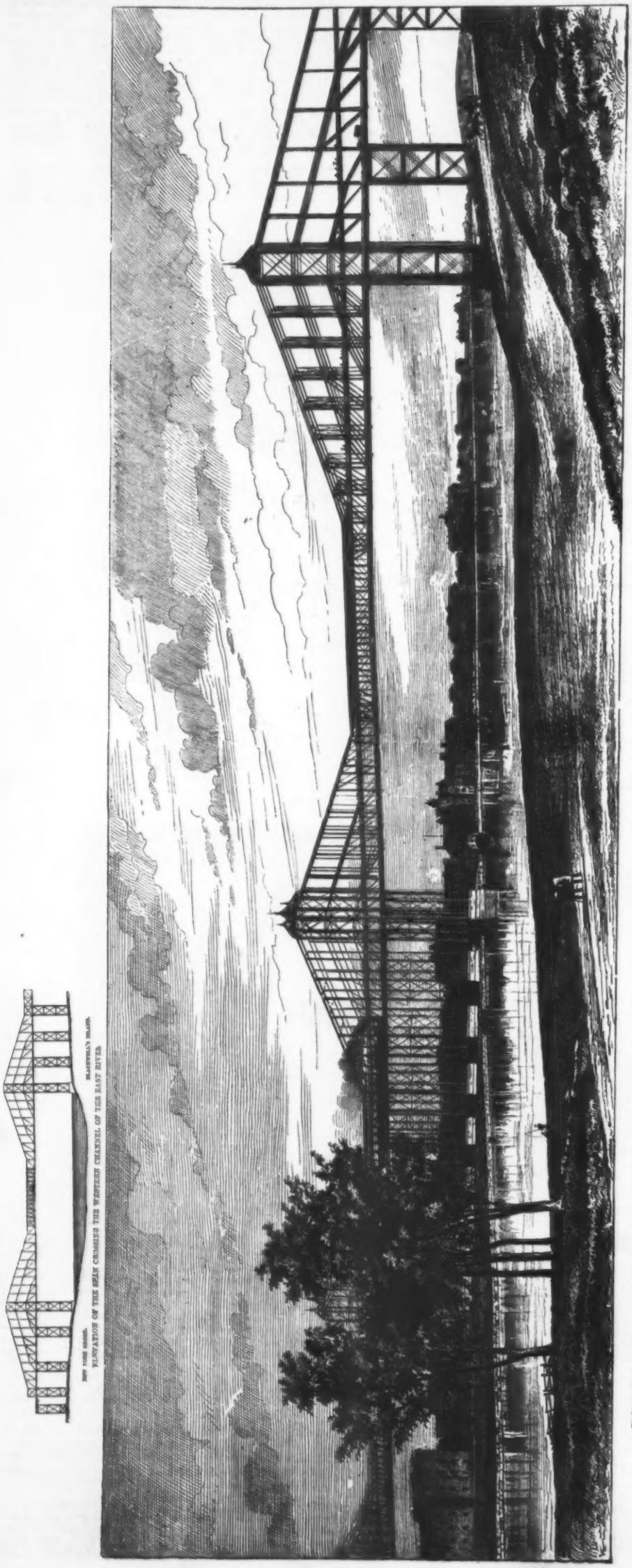
With augmented pumping power this question was set at rest by the complete fracture of a single riveted seam (machine work) at 275 lbs. pressure, when the rent extended the whole width of the plate, and passed into each side ring plate, the rent being about 5 ft. 6 in. long, and such as would most inevitably have caused the whole shell to open out with most destructive results.

boiler had gone through, a somewhat unexpected fracture took place in the only remaining external cast iron seating, viz., that below the boiler at the front end furnished for attaching the blow-off elbow pipe to. At 300 lbs. pressure this casting gave way, tearing the shell plate longitudinally, as had been the case in all other such fractures, and straining the lower part of the front plate, together with the front internal manhole mouthpiece, inwards, and tearing the external angle-iron at the lower part of the boiler.

This had to be repaired, and thus, after it had by successive trials been shown that one cast iron part after another

is one of the oldest manufacturing institutions in the city, having been established in 1851. It supplies California, Nevada, Idaho, Montana, Arizona and Oregon with mining and other classes of machinery, and has an export trade to Mexico, British Columbia and the Sandwich Islands.

THE Portland Boiler Works, San Francisco, are giving work to 180 men at present, but while they were repairing the steamers "City of Peking" and "Tokio" they employed nearly 700. This was the first exclusively boiler-making establishment in San Francisco; established in 1859.



PROPOSED NEW BRIDGE OVER THE EAST RIVER, BETWEEN NEW YORK AND BROOKLYN. DESIGN OF C. McDONALD, C. E.

PROPOSED NEW BRIDGE BETWEEN NEW YORK AND BROOKLYN.

THE Directors of the New York and Long Island Bridge Company lately took final action on the report of the consulting engineers employed to examine the plans presented for the proposed bridge at the foot of Seventy-seventh Street, New York, crossing the East River and Blackwell's Island to the Long Island shore. A premium of $1,000 for the best plan was awarded to the Delaware Bridge Company for the designs of Mr. Charles Macdonald, President and Engineer. We give herewith an illustration of the most important part of the proposed structure as it will be seen from the corner of Eighty-second street and Avenue B, looking towards the southeast.

This bridge is a novel modification of the cantilever type of bridges. In a bridge of this pattern the two cantilevers, balanced over each pier, form brackets, the shore ends of which are anchored down, and their outer ends sustain a central span, merely resting upon them, and free to expand and contract with the changes of temperature. These brackets, therefore, perform a double function. They sustain their own weight and their proper rolling load to the extremity of their arms, and they also sustain the weight of the central span and its proper rolling load, extending between the ends of the brackets. The Delaware Bridge Company propose to avail itself of this division of functions by subdividing the cantilever vertically into three brackets, superposed to each other by means of intermediate chords as shown in the small drawing. The designer claims that, by this arrangement, the weight is kept as low as possible, and that by avoiding the necessity for carrying all the weight to the top of the central tower over the pier, there results not only great economy in this tower, but also in all the compression members of the web, which become of the simplest and most manageable lengths, while the stability is greatly increased, and the erection becomes so simple and cheap that the structure furnishes its own false works, except for the central space. Each cantilever, or bracket, is divided by the two intermediate chords into three subsidiary brackets superposed to each other, and 36 feet deep. These again are divided vertically into panels 30 feet long by the posts, those posts alone carrying the live and dead load, to which the diagonal ties are attached, the posts above these merely serving to carry the weight of the cantilever chords, and to prevent them from sagging below a straight line. The process of erection consists in extending the parts with a balanced beam, panel by panel, each side of the pier, using each subsidiary bracket as the foundation for that overlying it, and then, after the brackets are completed, rolling a counterbalanced wooden truss, 300 feet long, into the intervening space, on and around which to erect the central span, which is 200 feet in length. The shore ends of the cantilevers are sustained by three piers, through which the anchorage is distributed.

There are three trusses, the bridge being divided by them in cross section into two roadways, one for the railroad and the other for a double carriage roadway 20 feet wide, the sidewalks being placed on brackets overhead of the carriage roadway. When a second track is to be added, it is to be provided for by independent trusses on the other side of the carriage roadway, which would then be in the middle. The lower boom, or chord, is composed of 24 inch iron plates and 8 inch channel bars, riveted together into the form of a continuous box girder open at the top. The vertical posts consists of two channel bars each, latticed, and the diagonals and the suspension chains, or upper chords, are of flat bars, 6 inches wide. All the verticals, diagonals and suspension chains, or chords, are connected with each other and with the lower chord and towers by pin-joints. The towers are composed of posts made of plates and channel bars, latticed, and are braced both transversely and diagonally. The shore piers on which the arms of the cantilever rest, are similar to the towers, and anchored to the foundation, so as to resist both compression and tension. The floor consists of iron cross-floor beams, made of plates and angle irons and of longitudinal iron stringers, braced by diagonal lateral rods. The main cross-floor beams are suspended from the pins at each panel point. The sidewalks are carried on brackets fastened to the vertical posts above the main floor. The central span is a Pratt truss, with firm connections and a double system of diagonals. The posts and upper chords are made of plates and channel bars, and the tie rods and lower chords of flat bar-links, as in ordinary spans. This span merely rests upon the outer ends of the arms of the two cantilevers, one end being provided with rollers, to allow of expansion and contraction. The space crossing the western arm of the East River will be 740 feet in length and 135 feet in the clear above high water. A similar span of 618 feet crosses the eastern arm, and a trestle work approach, about 4,000 feet in length, extends to the high ground on the Long Island shore.

On the New York side it is intended to connect with the Fourth Avenue Improvement by an iron viaduct graded down to the level of Lexington Avenue, thence by a tunnel 1,000 feet long. The entire length of the bridge will be about two miles, and its estimated cost $2,500,000.

Provision will be made for two carriageways and sidewalks, with elevators near the river, and for the present a single line of railway by which means direct connection without change of cars may be made between the railroad system of Long Island, including Brooklyn, and all the roads centering at Forty-second Street depot.

In this age of progress the citizens of New York may well lay claim to a foremost position for their magnificent efforts in the direction of public works. With a Croton water system prodigal in its supply beyond precedent, a Central Park the gem of a continent, and the Brooklyn Suspension Bridge exceeding in length of span any similar structure in the world, they will recognize in this Blackwell's Island Bridge a means by which in perfecting direct railway communication with Brooklyn, and its unrivalled suburban surroundings, the city proper will be materially benefitted, while owing to the novelty and elegance of the design it will present a most attractive appearance. It is the intention to erect the main spans over the East River without obstructing navigation, and as the foundations for the towers can be laid upon the solid rock without the use of any of the expensive appliances required at the Brooklyn piers, the entire work can be completed within two years, and at a cost which, owing to the present exceptionally low prices of material, will render it a most remunerative investment.

The approach to the new bridge will extend from a connection with the tracks of the Harlem Railroad on Fourth Avenue in the vicinity of Seventy-third Street to the crossing of Lexington Avenue, whence will begin an iron structure curving to the center of the blocks between Seventy-sixth and Seventy-seventh Streets, and continuing eastward through the same to the west bank of the western channel of

the East River. The return carriage approach on the New York side will be from the vicinity of Avenue A, and on the Long Island side from the vicinity of Vernon Avenue.—*Daily Graphic.*

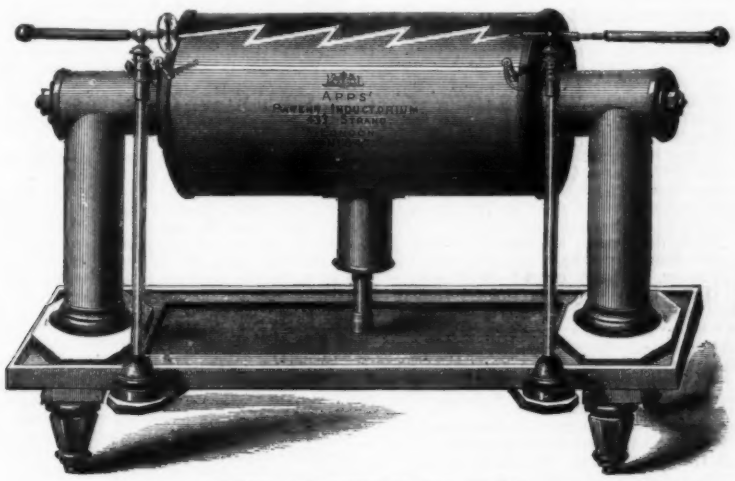
A NEW INDUCTION COIL.

A GIANT inductorium has recently been constructed for W. Spottiswoode, F.R.S., by Mr. A. Apps. The first instrument of comparable calibre was made for the Polytechnic Institution in 1869. Its construction caused much stir and awakened great hopes at the time. These, however, it has not realized, and the failure is perhaps less attributable to the inconvenience of the instrument than to the removal from the Institution of Professor Pepper, who best knew how to utilize its vast power and display its marvellous effects. This coil has now been for several years "on view" in the hall of the Polytechnic, where it is sure to produce effect, if not by its magnitude, at least by the contrast it makes with its immediate unscientific and puerile surroundings.

The new mammoth coil will not in all probability be consigned to such premature obscurity, for it is beyond the hampering solicitude of a committee of its management, being in the laboratory of a *savant* who is as diligent in his researches as munificent in his outlays, and who, moreover, has just declared the new instrument to be the common property of men of science. Mr. Spottiswoode made this generous statement in the lecture which he lately delivered at the Royal Institution, and the applause, however spontaneous and prolonged with which it was received, was but a prelude to the appreciation with which it will be hailed by the scientific public. The instrument is now fitted up in the laboratory at Sevenoaks, where investigators, desirous of extending their researches, will be welcome to the use of this new and vast source of energy.

An idea of the appearance of the coil may be gathered from the illustration. It is supported by two massive pillars rising from a mahogany stand which rests on castors. The central strain is supported by a pillar, which may be raised or lowered by means of a differential screw.

The coil is provided with two primaries, one being used for long thin sparks, and the other when short thick ones are required. The removal of one primary and the introduction of the other are easily and promptly effected. The same kind of copper wire is used for both, the different effects being obtained from a modification of the soft iron core. In the first primary (that used for long sparks) the core consists of a bundle of wires weighing 67 lbs., and forming together a solid cylinder 44 in. in length and 3½ in. in diameter. The copper wire is of 93 per cent. conductivity and has a total resistance of 2·3 ohms. It is 660 yards long and ·096 in. in diameter. It is wound in six layers and contains 1,344 convolutions. Its weight is 55 lbs.



NEW INDUCTION COIL.

The other primary has a core similar in construction. It weighs 92 lbs. and forms a cylindrical mass of soft iron 44 in. long and 3·8 in. in diameter. The copper wire is 504 yards long and weighs 84 lbs. It is wound in three layers, forming three distinct circuits, which may be connected in series or coupled together in threes. This novel arrangement admits of the employment of different battery power on the separate circuits; currents of different degrees of strength may be made to follow in regular succession as to time and duration. It is expected that careful sets of experiments, made in this manner, will lead to important results in the phenomena of the stratified discharge in vacuum tubes.

The secondary consists of 280 miles of wire, thus exceeding by 130 miles that of the Polytechnic. This wire has a conductivity of 94 per cent. and a total resistance of 110,200 ohms. It is wound in four sections, each consisting of about 200 layers. The diameter of the wire forming the two outer sections is slightly greater than that of the inner ones. This increase is intended to obviate any injurious effects that might arise from the accumulated charge which those extreme portions of the conductor have to carry. The total number of turns in the secondary is 341,850, the length of each gradually increases from 2¼ ft. to 5 ft. It has been thought desirable to increase the coil in diameter rather than in length, as experiments seem to indicate that the spark is due more to the number of convolutions than to the length of the wire, provided proper insulation be maintained.

The maintenance of this insulation in the successive stages of the coil is precisely one of the most vexed problems with which the constructor has to grapple; and the high degree to which it has been carried out in this powerful instrument is a monument *ære perennius* of the skill and ability of Mr. Apps.

It may be interesting, as affording an idea of the labor entailed, to know that each of the 800 layers was tested separately and then in sets, the results being carefully noted down for the purpose of comparison. Numerous experiments were made with varying current strength, and finally an extreme test was applied. This consisted in sending through the primary the current from a battery of 70 Grove cells; and when we add that no damage was done to the great induction coil, we have virtually said that its insulation is well-nigh perfect.

It might be supposed that the sympathetic impulse set up in the primary by the self-induction of the battery current, and technically known as the "extra current," would bear a direct proportion *cæteris paribus* to the magnitude of the coil; but this does not appear to be the case. The extra current on breaking—which is more mischievous in its effects than that on making—is certainly powerful; yet in the present case it does not require for its diffusion a larger condenser than that employed by Mr. Apps for his 10-in. spark coil. The present condenser, the result of several experimental trials, consists of 126 sheets of tinfoil, 18 in. by 8½ in., separated by varnished paper ·011 of an inch in thickness.

The power of a coil is usually estimated by the extreme distance between the two terminals of the secondary at which a spark may be obtained. It is obvious that this will in part depend upon the strength of the battery used. It may be pertinent to remark that the longest spark obtained from the Polytechnic coil was 29 in., and to produce this a battery of 40 Bunsen cells was necessary. With 5 quart cells of Grove, the new coil gave a spark of 28 in.; with 10 similar cells one of 35 in., and with 30 cells a spark of 42 in. As this last veritable flash of lightning was readily obtained, it is presumed that the full spark-giving limit of the coil has not yet been reached.

A variety of curious and interesting experiments has already been made. At the recent lecture, Leyden jars, globular in form and about 2 ft. in diameter, were charged to their utmost capacity by one single spark. Upon connecting three of these together and allowing as many sparks to pass, it was found that the middle jar—although made of thick glass—was perforated. A block of flint glass was shown, which had been pierced by a 28-in. spark, produced by the current from 5 quart cells. In some cases it was observed that the glass was not only pierced but also fractured. It is estimated that the 42-inch spark would perforate a block 6 in. in thickness. The volatilization of metals by the induction spark was readily shown, and by the introduction of the electric lamp and bisulphide prism, beautiful spectra were thrown upon a screen, and with such vividness as to render the colored bands and dark lines distinctly visible at considerable distance. It was noticed in the case of vacuum tubes that the illumination was very brilliant and of long duration, so that the backward and forward motion of the striæ could be easily detected by the unassisted eye. By introducing several Leyden jars into the secondary circuit, the non-striated character of the discharge through vacuum tubes was beautifully contrasted with the perfectly regular stratifications of the induced current.

The various phenomena of the striated discharge engaged, at an early hour, the attention of Sir W. Grove, and more recently was made the subject of an elaborate series of experiments by Mr. J. P. Gassiot. It has now, for some time, received much attention from Mr. Spottiswoode, and we believe that the new coil has been constructed mainly to enable him to clear up a few doubtful points, and bring his investigations to a successful issue.

It was certainly a happy idea of Mr. Spottiswoode to exhibit, for the first time to the public, the unprecedented power of his new coil in the theatre of the Royal Institution. No fitter place could have been selected than that in which the prince of experimenters discovered the phenomena of induction and penetrated their meaning with keen investigation.—*Engineering.*

TYPE PRINTING TELEGRAPH INSTRUMENTS.

THE subject lately brought before the Society of Telegraph Engineers, London, on the 14th ult.—the "Type Printing Instruments employed by the Exchange Telegraph Company"—was one of interest as illustrating a method by which a universal distribution of news may be effected in a readable form. As is no doubt pretty well known, the Exchange Telegraph Company was established mainly for the ready circulation of Stock Exchange prices and variations. The ordinary telegraph, whether of the Morse, needle, or other form of instrument, would accomplish this as readily and as accurately as does the apparatus dealt with by Mr. Higgins in his paper on the above subject; but any one of these systems would necessarily entail the services of an experienced telegraphist to operate the instrument and to translate the characters recorded by it. Such a condition would naturally prove obstructive from a commercial point of view, or, at all events, if not obstructive, restrictive in the number of users, as it must perforce increase the cost of the supply. The instrument used by the Exchange Telegraph Company prints its communication in bold Roman capitals, or figures, as may be required. It is self-starting, and thus claims no attention on the part of the receiver or subscriber to whom the news is sent, who, whether out of his office or in it, has merely to pick up at convenience the slip of paper on which the communication is printed and read off its contents as he would any other printed matter.

The form of instrument, though not generally known in England, is yet extensively used in America. Its origin is to be found in a form of step-by-step type-printer invented by Mr. E. A. Calahan, of New York, in 1867. Three wires were first employed to operate it. Modifications and improvements have, from time to time, been effected, of which that known as the Phelps and Manhattan are instances both as regards its mechanical and electrical parts. They are more rapid in working, but they are also more delicate and complicated than the substantial and simple forms of Calahan and Edison. The latter requires two wires, one to work the type-revolving, and the other the printing, apparatus. When more than one circuit is worked from the same transmitter relays are introduced, and these tend to reduce the speed at which the apparatus can be worked with reliability, owing to the disintegration of the relay contacts due to what is known as extra currents from the magnets in circuit, changes in the duration of the impulses due to the mechanical and electrical inertia of the relays, and the difficulty of sending more than ten pulsations per second, due to the distances at which the relay contacts had to be set when the sparks discharged from the line are of any great intensity. Efforts made to improve the transmitting apparatus were attended with but partial success. Twenty-two revolutions of the type-wheel per minute only could be effected; and a change in its construction was found to be necessary before a further increase in speed could be hoped for. Accordingly to this Mr. Higgins' attention was directed. His first step was to halve the number of teeth in the escapement wheel of the receiver, and so arrange that for the attraction of the type-wheel armature the wheels should advance a distance equal to one character, and for its recession another. To this purpose it was necessary that while one battery supplied both lines, a current should be sent on the "printer" line at certain times when the current was flowing through the "type" line, and again at certain times when it was not. This differed from the old form in that with it no current whatever traversed the "type" wire at the time a current was passed through the "printer" wire.

This done, Mr. Higgins next turned his attention more particularly to the electrical arrangement of the receiving apparatus. It is generally understood that whereas the strength of an electro-magnet varies at the square of the length of its cores, the time required for magnetization, and consequently for demagnetization also, increases with the length of such cores. Hence the number of defined pulsations which can be obtained from such a magnet varies according to the length of its cores, the shorter having the advantage, and this fact was turned to account in the present instance. Other improvements, having for their object the elimination of induced currents, were also effected. A point of considerable interest is the fact, elicited by Mr. Higgins in his investigations for the improvement of this form of apparatus, that cores of electro-magnets hollowed out in the centre to within a short distance of the top, to within one-third of their diameter, and the closed cylinder thus formed split to prevent the formation of induced currents, and annealed without coming into contact with the air, possess, if anything, greater attractive power than do those of the solid form. It is stated that electro-magnets so constructed have responded correctly to 2,700 currents (with reversals) per minute. Improvements in the escapement, in the relay contact points by the employment of a condenser to receive and return back into the line the extra currents induced in the electro-magnets and others of an auxiliary character, combined with those already indicated, resulted in the attainment by the Exchange Company of a much higher speed than was hitherto possible. The instruments thus modified are capable of a maximum speed producing 80 revolutions per minute with from 25 to 45 receivers in circuit. By the employment of an automatic switch arrangement fixed at the receiving station, one wire only need be employed, and by the same means the communication may be confined to two classes of subscribers, that sent to the one being cut off from the other.

The paper further entered into an accurate description of the automatic transmitter employed, the localization of faults and other points of interest, and was well illustrated by diagrams and apparatus in work.—*Engineering.*

WOOL DYEING.*

By GEORGE JARMAIN.

During the last twenty years, that is, since Mr. Perkin patented the process for the production of a mauve dye from aniline, in the year 1856, the woolen-dyeing trade has experienced great changes in the modes of performing many of its operations. The introduction of a large number of new dyes, through the discoveries of chemists, has necessitated these changes.

The dyer of the present day has, therefore, been educated to the fact that he owes a considerable number of his most beautiful colors to the chemist, and he has even received lessons in dyeing from him, for Schutzenberger and Lalande have taught the indigo dyer that he can dye a piece of cloth by other processes besides that of the woad vat.

The dyer has, in fact, received so many helps from the hands of the chemist that it is difficult to understand why he does not more frequently endeavor to make himself acquainted with the principles of the science which he must see is more competent than any other kind of knowledge to enable him to excel in his art.

Oftentimes when I see the skill which, with long practice and observation, enables our working dyers to produce the excellent work which they turn out, I feel persuaded that, were his practice and observation combined with correct scientific knowledge, the British working dyer need fear no rival which any country could produce. He would do well, however, to take to heart the fact that, however much practice he may have as a dyer, and however close his observation may have been, if he does not use the means to enable him fully to comprehend the nature of the operations which he is performing, he will, in the long run, be outstripped by those who have the good sense to combine theory and knowledge with practice.

On the other hand, the chemist is not always competent to give a satisfactory account of some of the ordinary processes of the dye house, processes which seem to him but ill adapted to accomplish the objects which the dyer has in view, but which, nevertheless, the dyer does accomplish.

Such being the case, it is very desirable that the chemist and the dyer should work hand in hand, and thus each in turn benefit the other.

WATER.

This indispensable article claims our first attention. I may say that the success of the operations performed upon wool

* A lecture before the Society of Arts, London.

in the various processes of scouring, rinsing, bleaching, and dyeing, will depend very much upon the character of the water employed. It is, therefore, of prime importance that the quality and suitability of the water for the operations intended to be carried on should be ascertained, before establishing new works or removing to others already in operation.

Having had a large number and great variety of waters to examine from time to time, in order that their suitability for woolen manufacturing purposes might be ascertained, I have arrived at the following results, which I may term limits of impurity in water suitable for wool scouring and dyeing. The water must fulfill the following conditions:

1. It must not exceed 7 degrees of hardness by Clark's soap test, of which it should lose not more than 2 degrees by boiling for an hour, and returning the water evaporated.

2. It must not deposit a brown sediment of oxide of iron when exposed freely to the air for some hours, nor must it give a blue coloration when a few drops of a solution of red prussiate of potash are added to a portion of it.

3. A portion of the water contained in a white glass bottle, to which a few drops of a solution of logwood are added, should be colored of a sherry color, which may be compared with a portion of distilled water treated in the same way.

4. The water should be clear, and must not throw up a brown scum of oxide of iron or organic matter when heated up to the boil.

5. Samples of wool or woolen fabric mordanted and dyed with the colors required, should compare well with similar samples mordanted and dyed with distilled water, or any other water known to be good.

A water which fulfills the above conditions is suitable for scouring and for the dyeing of woolen colors. Any considerable departure from these conditions will be attended with unsatisfactory results, unless the water be submitted to some treatment or purification.

The actual examination of the water is performed in the following manner:

1. *Clark's Soap Test.*

This test gives such abundant and important information to the scourer, dyer, and steam-user, that I venture to repeat such details of it that any intelligent operative may apply it to the examination of the waters in which he is most interested. The following are the apparatus and materials employed:

One burette divided into 50 cubic centimeters, in $\frac{1}{2}$ or $\frac{1}{10}$ cubic centimeters, stoppered.

One stand and clamp to hold ditto.

One 100 cubic centimeter measure.

One stoppered bottle, about 16 ounces capacity.

One pint of soap test.

One 16 ounce flask, fitted with a perforated cork, through which passes a glass tube $\frac{1}{4}$ inch bore, and about 4 feet long.

One 3 inch funnel and filter paper.

One retort stand, with Bunsen burner or spirit lamp.

The soap test should be bought of any operative chemist, for it is somewhat troublesome to make. Directions for preparing it, however, may be found in many of our standard textbooks of chemistry. The soap test consists of a solution of soap in dilute methylated spirit, of such a strength that, when shaken up with a definite quantity of water, it will indicate the amount of soap-destroying materials or hardening matters contained in the water. The operation is performed in this way:

Measure out 100 cubic centimetres of the water to be tested, and pour it into the clean and empty stoppered bottle.

Fix the burette in the clamp, and pour into it the soap test up to the top mark.

Run out the soap test through the glass stopper of the burette into the bottle containing the water, in small portions at a time, shaking the bottle vigorously after each addition; continue this operation until a full lather is formed on the surface of the water, which remains covered with the lather for five minutes.

When this point has been arrived at, read off the number of cubic centimeters which have been run out of the burette, and look for the degree of hardness in the table furnished by Dr. Clark, and which is here appended:

Table showing the Degree of Hardness.

Degree of Hardness.	Soap test measure.	Difference as for the next Degree of Hardness.
0	1·4	
1	3·2	1·8
2	5·4	2·2
3	7·6	2·2
4	9·6	2·0
5	11·6	2·0
6	13·6	2·0
7	15·6	2·0
8	17·5	1·9
9	19·4	1·9
10	21·3	1·9
11	23·1	1·8
12	24·9	1·8
13	26·7	1·8
14	28·5	1·8
15	30·3	1·7
16	33·	

The first column gives the degree of hardness, the second the number of soap test measures, and the third is a useful number for determining the fractional part of the next degree—it is the denominator of a fraction of which the excess above the number indicating the nearest whole degree is the numerator.

If, as sometimes happens, 32 measures of the soap test are insufficient to produce a lather, 50 cubic centimeters of the water are taken, and 50 cubic centimeters of distilled water added, and the hardness of the mixture is determined, the double of which is the true hardness of the water.

The hardness of the water, as determined above, represents the absolute or total hardness caused by the soap-destroying ingredients contained in it, which may consist of bicarbonate of lime, bicarbonate of magnesia, bicarbonate of iron; sulphate of lime, sulphate of magnesia, sulphate of iron; chloride of calcium, chloride of magnesium; free acids, and acid salts.

The degrees of hardness are determined in terms of carbonate of lime or chalk, each degree representing one grain of carbonate of lime per gallon. If hardening matters other than carbonate of lime are the cause of the hardness, then they are present in the following approximative relative proportions, if the whole hardness be due to these bodies respectively:

	Equivalents.
Carbonate of lime	100 parts.
" magnesia	84 "
" iron	116 "
Sulphate of lime (dry)	136 "
" magnesia (dry)	120 "
" iron (dry)	152 "
Chloride of calcium	111 "
" magnesium	95 "

That is to say, 100 lbs. of chalk dissolved in a certain bulk of water will make the water as hard as if it had dissolved in it 84 lbs. carbonate of magnesia, 116 lbs. of carbonate of iron, and so on with the rest.

When water containing the bicarbonates in solution is boiled they are decomposed, carbonic acid being expelled, and they are converted into insoluble carbonates, which precipitate or form an incrustation on the vessel in which they are boiled.

It is often of great importance to the dyer and steam-user to know how much of the hardness of the water is due to the presence of these bicarbonates.

Proceed in this way: Pour 100 cubic centimeters of the water into a clean flask fitted with a cork and a long straight tube. Boil gently for an hour, taking care that little or no steam escapes from the top of the tube, filter back into the measure, making the bulk up to 100 cubic centimeters with distilled water if necessary, then take the hardness with the soap test, with the precautions given above. The hardness thus obtained is due to the presence of bodies other than bicarbonates, and is called its permanent hardness, and the loss of hardness by boiling is due to the removal of bicarbonates; the hardness so lost is called "temporary."

The following example will show how the results of an examination of water by the soap test should be calculated:

A sample of water took 59·6 cubic centimeters to produce a persistent lather, and after boiling one hour and filtering it took only 7 cubic centimeters.

Therefore—

Total hardness	= 28·5	= 14	degrees.	
	= 1·1	= $\frac{1}{1}$	= $14\frac{1}{1}$	
Permanent do.	= 5·4	= 2		
	= 1·6	= $\frac{1}{1}$	= $2\frac{6}{11}$	
Temporary do. / The difference or loss	=	=	12 nearly.	

2. *Examination for Iron Compounds.*

These form a very objectionable impurity, for many colors cannot be dyed satisfactorily if iron be contained in the water, even in small quantity. The iron is usually present in the water in the form of bicarbonate or sulphate of the protoxide (ferrous bicarbonate or sulphate), the former being the more frequent form. When the iron is present in appreciable quantity, its presence betrays itself by the water becoming turbid when exposed to the air in an open vessel, and, after a few hours, a reddish brown sediment is found at the bottom of the vessel, the water having more or less regained its clearness. The deposit consists of the iron converted into the condition of insoluble hydrated peroxide (ferric hydrate) by the oxidizing action of the air.

The iron may also be detected by adding a few drops of a solution of red prussiate of potash, which will give a blue coloration in such water. When present in small quantity, the iron may be found by boiling a portion of the water down to about one tenth its bulk in a dish or flask; the iron, as peroxide, will then be found as a brown sediment, which may be dissolved in a little hydrochloric acid, and the above test applied to the solution.

3. *Examination with a Decoction of Logwood.*

A decoction of logwood is an extremely delicate reagent, showing by the various tints which it assumes the impurities contained in the water. The decoction is made by boiling about 1 ounce of logwood chips in 4 ounces of distilled water for a few minutes, allowing it to stand till quite cold, and then filtering it.

The water to be tested should be poured into the 100 cubic centimeters measure, or into a tall white glass bottle; a few drops of the infusion are then dropped into the water, and the coloration observed without stirring up the water.

The following reactions will be observed:

Distilled water	A brown amber or sherry color.
Water containing only—	
Calcic sulphate of chloride	Red amber becoming red brown.
Magnesic do	Amber becoming more brown.
Calcic bicarbonate	Red claret passing to a bluer shade.
Magnesic do	Red claret becoming more blue.
Ferrous bicarbonate or sulphate	Olive black becoming blue black.
Alkaline carbonates, carbonate of potash or soda	Dark cherry.
Free acids	Light amber.

The depth of coloration is in each case in proportion to the amount of the special impurity in solution. When there is a mixture of impurities the coloration partakes also of a mixed character, but a departure from the standard of distilled water is readily recognized, and should not be considerable.

4. *Organic Matter.*

The presence of organic matter, in quantity which would prove injurious in the woolen industry, generally betrays itself by the brown coloration which it gives to the water, or by separating as a brown scum when the water is raised to the boil. This brown substance may, however, readily be mistaken for oxide of iron, which it frequently resembles very closely in color; a portion of it should be removed, dried, and burnt. If it be organic matter, it will burn almost completely away; if it be oxide of iron, a red powder will be left.

5. *The Dyeing Test.*

To test the water, in order to ascertain whether it may be suitable for use for obtaining any particular colors, it is advisable to dye with it in a small way samples of the wool; at the same time, for comparison, samples should also be dyed, using distilled water, or water known to be good for dyeing, taking every precaution to use in each case the same weight of materials and dyes, and the same temperature and time; and particular notice should be taken whether any marked change of color takes place when the goods are finally rinsed or washed off in the same water.

The particular colors to be tried will readily suggest themselves to the dyer.

These small operations are best performed in an enamelled iron pan heated over a powerful gas burner.

Having examined the water by the five operations described above, a good knowledge will have been obtained of its capabilities to fulfill the conditions required of it, and any obnoxious substances will have been detected.

INFLUENCE OF THE IMPURITIES CONTAINED IN WATER ON THE OPERATIONS OF SCOURING, RINSING, AND DYEING.

1. *Calcareous and Magnesic Impurities.*

Influence on Scouring with Soap.—These impurities, in whatever form they may be present in the water, decompose and destroy as a detergent their equivalent quantities of soap, by converting it into a lime or magnesia soap, which is insoluble and greasy, and not only non-detergent, but it adds to the difficulty of the subsequent thorough cleansing. Every pound of chalk or carbonate of lime dissolved in water destroys 10 lbs. of soap. The insoluble soap so formed cannot be washed out from the wool or fabric, to which it attaches itself with great tenacity, and is frequently very mischievous in the dye bath, producing irregularity in the reception of both mordant and dye. I have therefore mentioned 7 degrees of hardness as the furthest limit at which it will be found advisable to employ water for scouring purposes when soap has to be used.

Even during the rinsing or washing off the wool or fabric where soap has been used, the mischief is increased by the fresh water acting upon the excess of soap which has to be used to obtain a scour; this excess is also converted into insoluble soap, and is added to that already formed.

Influence on Scouring with Alkaline Carbonates and Urine.—Calcareous and magnesic salts, when heated up with alkaline carbonates, precipitate their carbonates in a powdery condition, which may readily be removed by washing, but as wool generally contains a portion of natural fatty matter which forms a soapy emulsion with the alkaline carbonate, the presence of calcic and magnesic compounds interferes with the detergent action of the alkalies. The bad effects, however, are not so great as when soap has to be employed for scouring.

Influence on Mordanting and Dyeing.

Calcic and magnesic salts, when in the condition of sulphates or chlorides, appear to have no influence over the reception of either mordant or dye; waters containing them act, so far as woolen dyeing is concerned, as pure water.

When the salts are in the condition of carbonates, held in solution by carbonic acid (so-called bicarbonates), they are often exceedingly troublesome.

1. They diminish the effect of the mordant, and necessitate great care in counteracting this evil tendency by the use of an acid of tartar.

2. They produce a different shade of color in most cases in the dye bath, and require great skill and experience to obtain uniform results.

In fact, the dyer has a host of complaints to make against these earthy carbonates, for they blue his cochineal scarlets and purples; they blue the reds of his red woods; they strengthen the colors of logwood, fustic, and bark, but at the same time the colors lose their brightness, and the strength of color is not permanent; they destroy his tartar, which expends itself in converting the earthy carbonates into tartrates; they act generally as a diminution of mordant.

2. *Impurities in the form of Iron Salts (Ferruginous Waters).*

Their Influence on Scouring.—With soap they act like the calcic and magnesic salts, producing an iron soap which adheres to the wool, and is more mischievous than even the lime and magnesia soaps, for it seriously affects the colors afterwards dyed upon the wool. With alkaline carbonates (soda ash, urine) the oxide or hydrate of iron is precipitated, which adheres more or less to the wool or fabric, and is a constant source of anxiety and annoyance to the dyer.

Their Influence on Dyeing.—As iron compounds always have the effect of saddening colors, it is hopeless to expect to obtain any bright shades of color when a ferruginous water is used. Even with the dark and sad shades, and blacks, the use of this description of water frequently produces unsatisfactory colors. I have often seen cloudy and rusty spots on pieces which have been dyed with such water.

3. *Impurities in the form of Alkaline Carbonates.*

Influence on Scouring.—When the water is not also charged with earthy carbonates, the presence of these carbonates is beneficial rather than otherwise in scouring with either soap or alkaline carbonates.

Influence on Dyeing.—I know of no condition of water which is more troublesome to the dyer than this alkaline condition. In the mordanting they precipitate the bases of iron, tin, and copper salts, and of alum, and reduce bichromate of potash to the condition of yellow chromate, a much less effective mordant. They act on mordants in a similar manner to what the earthy carbonates do, but the action is sharper and more decided. Their evil influence can only be prevented by the use of an acid to neutralize the alkalinity of the water.

In the dyeing with this alkaline water the greatest care and skill are required, otherwise the colors will be affected, and in the rinsing or washing off, the colors, which may have been set right in the dye bath, will be thrown altogether wrong again by the alkalinity of the wash-water.

I repeat, I know of no condition of water which is more perplexing to the dyer than this alkalinity; and, unfortunately, it is of too common occurrence in some of the woollen districts of Yorkshire, where the dyer derives his supply from wells, or by boring into the lower beds of the coal measures, which appear to be charged with carbonate of soda.

4. *Organic Impurities.*

Waters charged with organic matters, in sufficient quantity to give them a color, are not suitable for bleaching wool, as they tend to stain it; but I have not met with any cases in which they have proved prejudicial for scouring or dyeing, except the organic matter be in the form of dye-waters from other works. Even the peaty waters from our Yorkshire moorlands do not seem to have any prejudicial influence on the dyeing of wool or woolen fabric; at any rate, no cases have come under my notice.

5. *Impurities in the form of Free Acids or Acid Salts.*

I have met with two classes of these waters: (*a*) Waters containing peaty acids. (*b*) Water running from pyritic shales near the surface, which by oxidation charge the water with sulphate of iron. On exposure, much of the iron deposits leave the water acid with free sulphuric acid. Both

these waters are exceedingly injurious to steam boilers. The acids become concentrated by evaporation in the steam boiler and attack the iron plates.

A new boiler, for which the first class of water was used, had its half-inch plates perforated after three months' use, and the tubes of a multitubular boiler had to be removed after using the second description of water for a few months. Both waters were entirely corrected by the addition of a little lime. They neither of them contained a trace of lime.

These waters are unsuitable for the treatment of wool. The second one decomposes soap, and liberates the fatty acids contained in it, which attach themselves to the wool in the same manner as the lime and magnesia soaps which I have already described.

PURIFICATION AND CORRECTION OF WATERS WHICH ARE TO BE USED IN THE TREATMENT OF WOOL.

The treatment of water which is required in such large quantities for the scouring and dyeing of wool and woolen cloths is always troublesome, costly, and unsatisfactory, at the best, and it is advisable to avoid all such treatment when possible, by obtaining the water from another source, or even by removing to new premises where suitable water is obtainable.

In case, however, no such course is practicable, the following processes may be employed, in order that the evil effects of unsuitable water may be mitigated:

1. *Exposure to Air, Subsidence, and Filtration.*

When the impurities consist of matters in suspension or of bicarbonate of iron, exposure to air in a shallow reservoir, and subsequent filtration through a bed of sand, will generally be found sufficient. The iron will be oxidized and rendered insoluble, and is then capable of removal by filtration. I have seen its removal effected satisfactorily by passing the water through a bed of shoddy, which acts as a very good filter.

2. *Treatment with Lime and Subsequent Subsidence (Clark's Softening Process).*

This treatment is only applicable to water that contains chalk, carbonate of magnesia, or iron salts in solution. The lime combines with the carbonic acid, which holds the carbonates of lime and magnesia in solution, which are thus rendered insoluble and precipitate along with the lime added. This mode of treatment is theoretically very perfect, but there are practical difficulties in the way of treating large masses of water which render it very difficult to manage. If too little or too much lime be added, the water is often made worse, and the point at which sufficient lime has been added is not very easy to determine. If a day's consumption can be treated at one time, the proper quantity of lime to use can be determined by treating separate small quantities of the water with known but varying weights of lime, and after allowing it to subside over night, that proportion which has softened the water most can be determined by the soap test. The quantity of water for a day's consumption should be treated with the calculated weight of lime, which should be mixed with water, and run into the reservoir, and the whole must then be agitated. This should be done at the close of the day. The carbonates will have subsided before morning. Water thus treated is very bright and clear, and if managed successfully will be found to be moderately well adapted for the treatment of wool.

3. *Treatment with a Ferric Salt, and then with Carbonate of Soda.*

This method is well adapted for the removal of soluble organic impurities and suspended fine clay. It has been applied by Dr. Gunning with great success to the turbid waters of the River Meuse. For the treatment of 3,000 gallons, 1 lb. dry perchloride of iron is dissolved in water, and then thoroughly mixed with the bulk; 1 lb. of soda ash of 52 per cent. is then dissolved, run in, and the whole again agitated. The hydrated peroxide of iron deposits, carrying down with it the organic impurities, common salt being the only substance left in solution.

4. *Treatment of Permanently Hard Waters (Wanklyn's Method).*

As has already been explained, these waters contain the sulphates of lime and magnesia, which have always proved to be the most difficult of removal. Mr. Wanklyn has recently proposed to soften waters of this class by first adding bicarbonate of soda and then lime. The bicarbonate of soda first converts the sulphate of lime into bicarborate of lime, and the subsequent addition of lime precipitates the bicarbonate so formed. Sulphate of soda remains in solution in the water.

I have not had an opportunity of seeing this process tried on a large scale, but I consider it likely to accomplish the end in view, if its cost should not prove to be a bar to its use.

5. *Treatment of Hard Waters with Soap.*

If hard water must of necessity be employed for scouring with soap, it is advisable to separate the hardening matter, by mixing a sufficient quantity of a hot solution of soap with it, and then causing it to run through a filter-bed before use. The insoluble soaps will thus be separated without attaching themselves to the wool or fabric, and they may be collected and treated with hydrochloric acid, to decompose them and separate the fatty acids, which may then be collected and reconverted into soap, by boiling them up with caustic or even carbonate of soda, and the soap thus obtained may be used again for the same purpose. Water thus treated is well adapted for the scouring of wool and woolen goods.

6. *Treatment and Correction of Waters in the Dye-bath.*

Organic matter, oxide of iron, and often a considerable proportion of the hardening matter, may be caused to rise to the top, and may then be skimmed off, by dissolving alum in the water in the proportion of about 4 ozs. per 1,000 gallons, and then raising it to near its boiling point.

In preparing waters which contain alkaline or earthy carbonates or bicarbonates, as a bath for either mordanting or dyeing, they should be treated with sufficient sulphuric acid to expel all the carbonic acid, and to neutralize any alkali which may have escaped washing out from the scour.

The use of bran is frequently serviceable in removing impurities from water in the bath.

Purification of the Refuse Waters from Woolen Mills.

In concluding my remarks on the subject of water, I beg to draw attention to the fact that the refuse-waters from a woolen manufactory contain within themselves the elements of their own purification. At the present time, the practice is to turn these refuse-waters into the river courses as they are done with. Sometimes mordant-baths are run out; at other times the spent dye-baths, and soap, or alkaline fluids. These mingle in the common receptacle, the river, and precipitate each other there, thus producing those black deposits which give to our streams in the woolen districts such an inky and foul appearance. I have mixed together solutions of all the substances used in our woolen industries, and find that they precipitate one another, and leave the supernatant water in a tolerably clear condition. The remedy seems to be, so far as the woolen trade affects the purity of the rivers, to run all the liquids into one common reservoir, and, after subsidence, to pass, if necessary, the supernatant water through a filter-bed into the river. The utilization of the black, muddy deposit would, I believe, speedily follow.

SCOURING.

I have now to draw your attention to the cleansing of wool and woolen fabric, in preparation for its subsequent treatment in the dye-house.

Raw wools always contain a considerable amount of organic and earthy impurities. The most abundant of these is suint, a peculiar organic body containing potash. M. Chevreul gives the following as the composition of merino wool:

Earthy matter	26·06
Suint	32·74
Greasy matter	8·57
Earthy matter fixed by the grease	1·40
Clean wool	31·23
	100·00

I am not aware that any attempt has been made in England to utilize the wool impurities. A very pure potash salt is, however, manufactured from them in France.

Scouring Materials.

The following are the detergents in use in the woolen industry: Urine, ammonia, soda ash, soda crystals, soap (hard and soft) silicate of soda, and various compositions containing carbonate of soda.

Many manufacturers prefer to use stale urine, which contains a considerable quantity of carbonate of ammonia, a particularly mild alkali. The organic matter in the urine appears also to assist in cleansing, and it protects the woolen fibre from injurious action by alkalies.

Ammonia is also a mild alkali, and for the treatment of wool, that distilled from urine is preferred to all other kinds. The strength of ammonia is determined by taking its specific gravity by means of a hydrometer called an ammoniameter. The one in common use in Yorkshire and Lancashire has an arbitrary scale, each degree equalling 3, water being taken at 1·000. Thus, the specific gravity of ammonia at 20 degrees equals $1·000 - (20 \times 3) = ·940$. The crude ammonia distilled directly from gas liquor frequently contains hydrocarbons and sulphide of ammonium. The former can easily be recognized by pouring some of the ammonia on a plate; after a few hours, when the ammonia has passed away, the tarry smell of the hydrocarbons will be perceptible. Sulphide of ammonium is readily distinguished by the dark color which the ammonia gives when treated with a solution of acetate of lead, or by the blackening of a silver coin when dipped into it; the black sulphides of lead and silver being formed respectively.

The hydrocarbons act strongly on the skin of the workman, and the sulphides act injuriously on the wool.

Carbonate of soda is the most extensively used scouring agent; it enters largely into the composition of many detergents bearing fancy names. The following are the principal forms in which it is employed in the woolen manufactory: Soda ash, containing from 30 to 52 per cent. available alkali; (oxide of sodium) soda crystals, containing 21·7 per cent. available alkali; soap ash, containing 21·7 per cent. available alkali, and a small quantity of soap, or palm oil; dry soap (good), containing ¾ carbonate of soda and ¼ soap; urine substitute, melted soda crystals.

The value of these substances as detergents is in proportion to the available alkali (oxide of sodium combined as carbonate) which they contain. Dry soap, however, contains in addition a considerable quantity of soap.

I have occasionally seen the workman gauging the strength of his soda ash liquors by means of a hydrometer; this is a foolish plan, because the salt and other impurities contained in weak soda ash add to the density of its solution, and give to it a fictitious strength.

It is important that the foreman should know what is the available strength of the soda ash he employs. I have found the following plan to give sufficiently accurate results in the hands of an intelligent workman:

Apparatus Required.—One burette, 50 cubic centimeters in ½; one holder for ditto; one 100 cubic centimeters graduated measure; one liter measure; one box, scales and weights to weigh to $\frac{1}{10}$ of a grain; one boiling flask; one filtering funnel and filter paper; one spirit lamp, or Bunsen burner where gas is in use; one retort or tripod stand, and a piece of wire gauze; infusion of litmus; 1 one-half oz. porcelain crucible; one 4 oz. beaker glass. Most of these are included in the soap test apparatus.

Two standard solutions are required, viz., standard sulphuric acid, and a solution of caustic soda which exactly neutralizes an equal volume of the standard sulphuric acid.

The acid is made of such a strength that 1 cubic centimeter of it neutralizes ½ grain of oxide of sodium (soda.)

The preparation is as follows: About 200 grains of pure carbonate of soda, or, failing that, Howard's bicarbonate, are heated to redness for an hour in the porcelain crucible over the lamp, to expel moisture, etc. When cold, weigh out carefully 171 grains of it, dissolve it in a little distilled water in the beaker, pour it into the 100 cubic centimeters measure, rinsings as well, and make up to 100 cubic centimeters with distilled water; pour into a bottle and add to it another 100 cubic centimeters of distilled water.

Every cubic centimeter of this solution contains ½ grain of oxide of sodium, and is used to prepare an acid solution of equal strength—the standard sulphuric acid.

The acid is prepared in the following manner: About half fill the liter measure with distilled water, pour into it 31 cubic centimeters of strong sulphuric acid, D. O. V. 170° Tw., fill up to the liter mark with distilled water, then pour into a bottle to mix it. This acid will be too strong, and will require an additional quantity of water; its actual strength, as compared with the prepared solution of carbonate of soda, must now be ascertained. Pour 100 cubic centimeters of the standard carbonate of soda solution into the boiling flask, add another 100 cubic centimeters of distilled water and a few drops of the litmus; fill the burette up to the top mark with the diluted sulphuric acid, and run it into the flask until the litmus begins to redden, then boil to expel carbonic acid; run in more of the sulphuric acid in repeated small quantities until the blue color begins to permanently redden, boiling after each addition. When the exact point has been reached, read off the number of cubic centimeters which have been used; if, say, 94 cubic centimeters of the diluted acid have been used, then the acid of the proper strength will be made by adding 6 of water to 94 of the trial acid; in order that this mixture may be made, pour 60 cubic centimeters of distilled water into the liter measure, fill up to the mark with the trial acid, and mix as before by pouring it into a bottle. This is the standard sulphuric acid, every cubic centimeter of which neutralizes half a grain of oxide of sodium, and which alone will enable the workman to test his soda ash and other materials depending for their value upon the available oxide of sodium they contain.

The process is as follows: Weigh out 50 grains of the ash, put it into the flask with 100 cubic centimeters of distilled water, and heat until dissolved; filter; if any portion remains undissolved, wash the filter, add a few drops of litmus liquid run in the standard sulphuric acid from the burette, and find the neutral point as before, boiling between each addition of acid until the litmus shows signs of reddening. Read off the acid taken; the number of cubic centimeters of acid required is the percentage of available alkali contained in the soda ash examined, no calculation being required, for each cubic centimeter of the acid neutralizes half a grain of oxide of sodium, and 50 grains were taken.

The operation may be shortened, and made more exact, by using a second standard solution, viz., one of caustic soda, which contains half a grain oxide of sodium per cubic centimeter. This solution is prepared by testing with the standard acid a solution of caustic soda made a little too strong, and then diluting it to standard strength in the same manner as was done with the sulphuric acid.

To test a sample with the two solutions, weigh out 50 grains, and dissolve, with the precautions given above; measure into it an excess of standard acid, say 60 cubic centimeters, if a strong soda ash be under examination; boil until all carbonic acid is expelled, add a few drops of litmus, which will redden if the proper amount of acid has been added, then neutralize the excess of acid by running into it from the burette the standard solution of caustic soda until the red color begins to turn to blue. The number of cubic centimeters of caustic soda required to do this is a measure of the excess of acid used; the percentage of available alkali is, therefore, ascertained by deducting the cubic centimeters of caustic soda from the cubic centimeters of standard acid used; the remainder represents the available alkali.

The following is an example: 50 grains of soda ash were dissolved in hot water and filtered into a flask, and 60 cubic centimeters of standard acid were added, and the whole boiled for ten minutes. Litmus was then added, and it was found that it required 8 cubic centimeters of standard caustic soda before the blue color of the litmus was restored. The percentage of available alkali was, therefore, $60 - 8 = 52$ per cent.

The process given above determines the true percentage of available alkali, and does not take account of the absurd standards which trade customs sanction in Liverpool and Newcastle.

The advantages derived from being able to ascertain the amount of alkali in a detergent are:

1. The manufacturer knows when he gets his money's value.

2. The workman knows when he is using the right quantity of materials.

Soap.—Soap consists of a fatty acid in combination with potash or soda, water, and impurities of no detergent value, or positively injurious. The value of a soap depends upon the amount and correct proportions of fatty acid and alkali. The former is determined by weighing out 50 grains of the soap, and boiling it in a beaker glass in distilled water till dissolved, adding 10 grains of solid paraffin, and then about 10 cubic centimeters of sulphuric acid, diluted in a little water; the whole is then boiled gently until the liquid clears and the oily matter completely rises; it is then set aside till quite cold, when the fatty acid can be removed in a cake, dried upon a blotting paper, and weighed. The weight from which the paraffin added must be deducted, gives the fatty acid, the double of which, if 50 grains have been taken, is the percentage.

The percentage of soda can be obtained in the same manner as is used in soda ash. In soft soaps, which contain potash instead of soda, the potash (oxide of potassium) is obtained by multiplying what is obtained by the soda process by 1·516, or roughly calculating for potash half as much more as the soda indication. The equivalent of potash is 94, and that of soda is 62.

Silicate of Soda.—This material is coming into favor as a detergent; it cleanses wool very satisfactorily, and leaves it in a suitable condition for the reception of dyes, particularly those of the aniline colors.

Wool Scouring.

The detergents used are, soft soap for fine long wools; and for short wools, both coarse and fine, urine alone, or urine and soda ash, or soda ash alone, silicate of soda, and various mixtures of alkaline carbonates and soaps.

The best temperature for the scouring of loose wool is from 125° to 135° F.

The old-fashioned mode of scouring wool, and which gives fair results, is to work it about in a kettle or tub containing the scouring liquid, with a stick or stang, for five or ten minutes, and then lift it out upon a scray, with the stang or a fork, by small portions at a time. When it has drained upon the scray, it is then thrown into a cistern called a "wash-off," the bottom of which is fitted with perforated iron plates. Water is then run into the cistern by a five or six inch pipe entering horizontally, and when full the wool is stirred up well in it. The water is then let out from under the perforated plates by means of a clack. The washing with water is repeated two or three times. This method requires an abundant supply of water, but is in other respects economical. An improvement upon this process, very often resorted to, is to have a perforated sheet iron shell swung on a trunnion, and fixed to a crane. The shell is lowered down into a scouring pan, and the wool scoured in it; when ready it is drawn out by the crane and the wool thrown out into the wash-off cistern by tilting the shell over. The wool is washed two or three times as before. One man can scour from 500 lbs. to 600 lbs. per day by the first mode; it requires two men to scour by the perforated shell, but more work can be got through.

For certain classes of wool, in which soap is employed as the detergent, the scoured wool is passed between rollers instead of washing it.

Long stapled wools are manipulated with forks by hand in the scouring fluid.

In most large factories, however, the above processes for

cleansing wool from their natural impurities have been superseded by the introduction of wool scouring machines, the first of which was invented in 1851, by Mr. John Petrie, Jr., of Rochdale, who has since that time very greatly improved the machine; in fact, the latest form of it, the "Paragon," as he calls it, leaves little to be desired.

A complete machine consists of three boxes or bowls. The wool is fed into the first by a boy. In this bowl a strong scour is placed, through which the wool is forked by forks ingeniously fixed to cranks; from this bowl it is passed through rollers into the second which contains a weaker scour; it then passes through rollers to the third, in which it is forked through running water; and lastly passes between heavy squeezing rollers and is thrown forward by a powerful fan which leaves it light and open. The wool is turned out very clean and half dry. In fact, the machine performs a large amount of work in a very satisfactory manner, and the manufacturers who use them tell me that they are very much pleased with them. McNaught's and Leech's machines, each possessing special features of their own, are also spoken well of by those who use them.

Yarn Scouring.

The impurities to be removed by scouring from woolen yarns are, oil which has been used to enable the wool to be scribbled and spun, and accumulated dirt. The detergent used is a mixture of soap and ammonia, but for some descriptions of yarns cheaper alkaline liquids may be used.

It is important that the felting of the yarn should be avoided as much as possible. This may be accomplished by steeping the yarn in hot water and leaving it to cool before scouring.

The scouring is done in a wood cistern filled with the scouring fluid; the yarn is hung on sticks placed across the cistern; it is turned over frequently, and worked about in the scour, and finally wrung out. The best temperature for the yarn scour is from 140° to 150° F.

Cloth Scouring.

This is always done in a machine consisting of a bowl or cistern, and squeezing rollers placed above. The scouring materials vary with the description of cloth, soda ash, soda crystals, and soap ash being usually employed for woolen cloths. The cloth passes through the scouring liquid heated to from 150° to 160° F., and then between the rollers for some time, whereby the oil contained in the cloth is removed in the form of an emulsion by the detergent. The scour is frequently used again, after being strengthened by the addition of more alkali. The cloth is finally washed in clean running water on the machine for a considerable time. The thorough removal of all oil soap and grease from the cloth is very important for the subsequent dyeing, for, if any remain in it, the action of the mordant is seriously interfered with.

WOOL BLEACHING.

The mode of bleaching woolen goods in general use at the present day is of a very primitive character, there having been but little improvement in the process since the days of Pompeii, in the ruins of which, Pliny tells us, there were found traces of the art. As in those days, so now, a closed chamber, in which the goods to be bleached are hung up, is filled with the fumes of burning sulphur, and the goods left exposed to the action of these sulphurous fumes for some hours, during which time the yellow coloring matter of the wool is more or less affected, probably by the reducing action of the sulphurous acid, whereby the coloring matter is transformed into a colorless substance. The bleaching, however, is not of a very permanent character, the color being liable to return, especially if the goods are treated with alkaline solutions, which frequently favor oxidation. The bleaching of wool with sulphurous acid is, therefore, not so satisfactory as the bleaching of cotton with chlorine.

Chlorine is not suitable for the bleaching of wool, for it attacks and damages the fiber without bleaching it. Sulphurous acid is the only bleaching agent which has proved effective for wool. The operation is called sulphuring, or stoving. The sulphur stove is built of brick or stone, and often lined with wood, as few nails as possible being used to prevent damage from sulphate of iron, which is formed by the sulphurous acid combined with air, acting upon the nails. The goods to be bleached are well soaped and washed, and while in a moist condition are hung up in the room. A quantity of sulphur is placed in an iron dish in the room, and a red-hot piece of iron is dropped among it; the door is then closed, and the room left undisturbed for some hours. The door is then thrown open, and the sulphurous acid gas escapes; the goods are then removed and washed, to free them from the sulphurous acid which, if left in contact with the fiber, would become sulphuric acid by the oxidizing action of the air.

Certain improvements have been suggested in the management of these sulphur chambers, having for their object economy in the use of sulphur; the more equal diffusion of sulphurous acid in the chamber, and, consequently, more regularity in its action; and, lastly, prevention of the destructive action on vegetation arising from the escape of the sulphurous acid on opening the door. In the *Moniteur de la Teinture*, for 1872, an arrangement is described which is likely to accomplish this object. Sulphurous acid, produced in a sulphur burner, is forced into the chamber by means of a small steam jet, and when the goods have been exposed in the room for the proper time, the sulphurous acid is drawn out by an aspirator, and is absorbed by carbonate of soda, which it converts into sulphate of soda. An additional improvement consists of an arrangement for passing the goods through the chamber by means of rollers. The bleaching of cloth can thus be made continuous.

THE SIZING OF COTTON GOODS.

MR. WM. THOMSON, F.R.S.E., of London, read a paper at the Society of Arts, London, on this subject, and in the course of which he said that the sizing of gray cloth, as it was carried on in Manchester, was one of the clumsiest and least understood processes with which the manufacturer had to deal. After describing the process of weaving, he showed that the warp, or longitudinal threads of the cloth, were submitted to great strain and wear and tear; and the process which was devised to give additional strength to the warp was called "sizing." For this purpose the threads were passed through some adhesive mixture, such as flour paste, to which oil or tallow had been added, to give a soft "feel," and thus to counteract the harshness which would be given to the threads by the flour paste alone. Only small proportions of those substances were required to give the desired strength, but as it soon became evident that size improved the appearance of cloth, manufacturers were not slow to take advantage of it, and now there was only a small proportion of gray cloth manufactured in Lancashire, a considerable proportion of the weight of which was not made up of flour, tallow, China clay, and other ingredients; but this "size" was not, as a rule, used by manufacturers with dishonest intention. The merchant who bought the goods clearly understood that they contained size, and, when they pleased him, he had but one question to ask before making his purchase, and that was: "Is the "size" good, or will there be any risk from mildew?" The onus of heavy sizing being thus thrown on the head of the merchants, they would tell inquirers that they purchased what the natives in the countries to which they ship their goods desire. The natives made different articles of dress with it, and did not wash it before wearing it; and they preferred to buy a cheap cloth, which had a good appearance, owing to the size which it contained, to paying the same price for a pure article through which the light could penetrate and show clearly each thread of the fabric.

As much vituperation has been levied against manufacturers for this apparently dishonest dealing, he would venture to defend them by taking a parallel case: Some years ago they heard a great deal about adulterated paper. An eminent chemist distinguished himself by pointing out the frauds which some paper manufacturers were practising, viz., of introducing sulphate of lime, better known by the name of plaster of Paris, and other mineral substances, into writing and other kinds of paper. The public then looked with indignation on the perpetrators of such frauds, and the representatives of Her Majesty's Government, in giving their orders for paper, stipulated that it should be pure—*i.e.*, made from pure vegetable pulp, and free from adulteration. Persons who had to use many of the cheaper varieties of this "pure" paper found it to be most objectionable stuff. The pen penetrated it with facility, and the writing showed almost as well on the one side as the other, and to these facts many have testified who have used the newspaper wrappers, which at one time were supplied by the post office. The paper manufacturer showed very good paper at the same price, but it was impure, as it contained about half its weight of plaster of Paris.

They had now, accordingly, got over their prejudices, and were content to write letters on and read the news from sheets of China clay or plaster of Paris, these ingredients having been mixed with vegetable pulp to make it stick together. We are a clean people. We wash our calico before wearing it, and our manufacturers are pleased to supply us, or what they call the home trade, with pure cloth. Their foreign brethren were not so clean. They preferred to clothe themselves with flour, tallow, and China clay, to which cotton had been added to make it stick together, and our manufacturers were sufficiently generous to comply, as far as possible, with their demands. Before the manufacturer used the flour, he fermented it for one, two, three, or more weeks, with the view to render it less liable to mildew. This fermentation was produced by certain living cells, which eat up or destroyed certain pabula contained in the flour, and the manufacturer thus inoculates his flour with a peculiar living cell for the same reason that we inoculate ourselves with vaccine lymph, so that the living cells of the lymph may eat up and thus destroy pabula in our blood, which would be liable to be attacked by the very objectionable germs of living cells of smallpox. He considered that this operation was not sufficiently studied by manufacturers, and that the ferment of the manufacturers should be treated with as much care and skill as the ferment or yeast cells of the brewer or distiller. Chloride of calcium and magnesium were now much used in sizing. They were better known under the name of "antiseptic," but he considered that the word "septic" would be more appropriate. It had the property of keeping the yarn moist, and so making it stronger, producing better weaving, and a larger average production of cloth per loom; but it was apt, unless its effects were counteracted, to produce mildew. Yarn or cotton in its normal condition contained about 8 per cent. of moisture, and he found, by taking the average of several experiments, that a "lea" of yarn (a small hank), in its normal state, was broken by a strain of 64 lbs. When the same amount of the same yarn was allowed to absorb moisture, its strength increased in a small relative proportion. Thus when the yarn contained 17 per cent. it broke with a strain of 69 lbs.; but when the natural moisture was abstracted from it, its strength decreased in a large relative proportion, so that the same yarn containing three per cent. of moisture broke with a strain of 40 lbs. This explained why cold or frosty weather produced bad weaving. Cold air contained much less water vapor than warm air, and when cold, and therefore dry, air entered a weaving shed which was constantly kept at a much higher temperature, the air was at once heated up, and required to saturate itself with moisture, which it did by evaporating off or absorbing the natural moisture of the yarns, and thus weakening them. In speaking of mildew, Mr. Thomson said that when yarn was seized it was quite free from any living spores, or seeds of fungi, or mildew, and that if it were then kept in an atmosphere free from dust it would be impossible for it to mildew, even if it were kept in a warm and damp place for an indefinite length of time. When bales of mildewed or damaged goods were sent home from abroad the recipient of them often destroyed most of the evidence against the party who was morally responsible for the damage by unpacking the bale, carelessly throwing about the packing, and separating and mixing up the pieces. Note should be taken in writing of every flaw or stain on the outside of any of the wrappers, and then on the outside of the block of cloth, and any stains on the cloth carefully compared with any flaws or stains in the package, etc., and every piece of cloth and packing replaced in exactly the same position in which it was found, for further examination if necessary.

MANUFACTURE OF ASPHALTUM.

THE essential property of the asphalt made according to the invention of Mr. E. Rocheman, Cairo, Egypt, is its power of entirely resisting solar heat without experiencing any depression in consequence of the softening of the material under the solar influence. Trials have also shown that it resists the action of cold, and that it does not experience under the influence of frosts any contractions resulting in fissures in the mass. It is to give the asphalt this property of resisting solar rays that Mr. Rocheman proposes to take as the base of his manufacture a particular clay called in geology fossil clay, and which is found in abundance in the old alluvial earths of Egypt. This clay is, therefore, the chief feature in his manufacture; it is to it the stability of his products is due, and also the hardness which they offer to the trampling of men and animals, as well as to the pressure and friction of vehicles; but in the manufacture of this asphalt clays of another kind, possessing of themselves the qualities of the fossil clays which are found in Egypt, or which are brought by different means to that state, are capable of producing the same results. In the process of manufacture the first operation consists in carefully grinding the clay either by hand or by suitable machinery until it is reduced to a state of impalpable powder in sifting it in order to remove foreign matters which may have got mixed with it, and in again reducing it. In this state it is necessary to be assured that it is as dry as possible, and if it is not in this essential condition the drying must be effected by any suitable processes which are prompt and economical; the clay is then ready for manufacture. As to substitutes for the Egyptian clay, he avoids especially saliferous clays, but for the most part, under the conditions hereinbefore explained, clays of all kinds can be advantageously employed when they are purified and carefully dried. Clays, he says, are, in a chemical point of view, hydrated or hydratiferated aluminous, silicates, sometimes mixed with more or less pure quartz sand, on account of their origin, which connects them with the destruction of different kinds of rocks. These clays purified will quite answer the purpose. It follows, then, from this essential consideration, that the more or less fine, or the more or less pure clays generally employed in the manufacture of bricks, and of fine or coarse pottery, pipes, crockery, and porcelain, are excellent materials for the manufacture of the asphalt; also, all *débris* of bricks, pottery, crockery, and porcelain, broken and pulverized. All these materials, the base of which is clay, have the property of absorbing bituminous matters, and of forming therewith compact and resisting mixtures, having properties such that they produce asphalts of very good quality, and capable of being applied for various purposes.

NOTES ON GAS MAKING.

By R. H. PATTERSON.

A NEW MODE OF WORKING WASHERS AND SCRUBBERS.

WASHERS and scrubbers have been employed simply to take out the ammonia from the gas, which is a highly profitable process owing to the commercial value of the ammoniacal liquor thus obtained. Originally, it is true, and up to a quarter of a century ago, washers were employed even in first-class gas works, as indeed their name implies, to merely *wash* the gas, chiefly in order to cleanse it from its tarry elements by cooling; and these vessels are still employed in this rude manner in small gas works throughout the country where condensers are not used; and even in larger works, but where the condensers are inadequate, a considerable portion of the tarry vapor is still taken out of the gas by means of the washers or scrubbers.

But in the London gas works, at least for several years past, the preliminary work of condensation has been done satisfactorily, and the washers or scrubbers have been employed entirely for the extraction of ammonia, which is readily absorbed by the water contained in these vessels. But this object, viz., the extraction of NH_3, has been the only one for which washers and scrubbers have been systematically employed even in the largest and best managed gas works. It is true, and has been well known, that along with and by the ammonia, a portion of the acidulous impurities, CO_2 and SH_2, was likewise absorbed in those vessels, but this happens simply as a necessary concomitant of the extraction of the ammonia (which, being an alkali, absorbs these acid impurities), and no special attention was given relative to this simultaneous extraction of CO_2 and SH_2, nor was any attempt made to regulate their absorption.

I may say much more than this, for the absorption of CO_2 in the washers or scrubbers was so wholly overlooked that it was practically forgotten that it was absorbed in these vessels at all. In proof of this I may refer to all the literature or publications on gas manufacture—"Clegg" in its successive editions included—but there is also direct and positive evidence upon this point in the opinions expressed by some of the highest and most scientific authorities on gas purification. These show that the liquor formed in the washers and scrubbers was regarded as, and practically treated as if it were, sulphide of ammonium—the presence of CO_2 in the liquor, usually in a preponderating quantity to SH_2, being totally ignored. This appears remarkable, but the mistake was not confined to gas liquor, for an exactly similar error, or forgetfulness, was made with respect to foul lime, which was regarded as sulphide of calcium, in other words, as if it were simply sulphuretted, instead of (as is the fact) three fourths of it being carbonated. Nor was this merely a vague abstract opinion, for Mr. Mann, one of the very ablest of the London gas engineers, in a patent which he filed in December, 1871, practically regards and explicitly speaks of foul lime as being sulphide of calcium, and of gas liquor as being sulphide of ammonium. Whereas, as is now acknowledged, the lime in purifiers, when worked by the system then in use, and also the ammoniacal liquor in washers and scrubbers, existed necessarily to a large and preponderating extent in the form of carbonates.

Another illustration of this wrong notion (viz., of the neglect and forgetfulness of the effects of the CO_2 in the gas) was given by Hawksley and Letheby in 1865. It happened in this way: The capacity of certain alkaline sulphides to absorb bisulphide of carbon had been ascertained in laboratory experiments by continental chemists; and Mr. Hawksley suggested that a means of extracting the CS_2, which was then and had long been an insuperable difficulty in gas manufacture, might be found by washing the gas with the liquor formed in the scrubbers, which he regarded as sulphide of ammonium. This attempt failed; the reason being now well known, viz., that the liquor was so carbonated, and therefore contained so little sulphide of ammonium, that it had no satisfactory action upon the bisulphide of carbon. Mr. Hawksley next recommended a very copious, indeed an enormous, washing of the gas with the scrubber liquor; but this also failed. Last of all, it occurred to them that the liquor, as ordinarily produced, was not "strong" enough (which was quite true, though in a very different sense from what was then imagined); and I remember Mr. F. J. Evans when he was a colleague of mine as a gas referee, used to speak hopefully (as a means of solving the sulphur question) of employing *very tall* scrubbers to effect Mr. Hawksley's object—the object of the tall scrubbers being to produce stronger ammoniacal liquor, and of such a quality as to be capable of purifying the gas from bisulphide of carbon. Now, this notion was doubly wrong. In the first place, the idea that scrubbers of unusual height are necessary for the production of strong gas liquor was as curious a misconception, or lack of knowledge, of the simple facts of the case as could well be imagined; because, as might be evident to every one, no new apparatus or heightening of the scrubbers was needed at all for such a purpose, for the liquor could be "strengthened" to any extent by merely returning it into the scrubbers, or, as it is technically

termed, "working it over again." In the second place, as I shall show, the liquor so produced was even less suitable for the proposed object than ordinary scrubber liquor is.

This plan for using stronger gas liquor, *i.e.*, liquor of greater ammoniacal strength, whether obtained by using tall scrubbers or otherwise, likewise failed, as it was bound to fail. Indeed, the result must have been worse than when ordinary gas liquor was employed, and the attempt showed more decisively than before the utter lack of knowledge which then prevailed on this subject. The cause of the failure was this: As I was the first to point out, and as is now fully recognized, the "stronger" the gas liquor becomes, the more does it become desulphuretted and converted into the inert form of carbonate. The only means of increasing the ammoniacal strength of the liquor is by keeping the liquor longer in contact with the gas, in order to promote the absorption of NH_3 by the water, which is capable of absorbing about 700 times its own volume of this gas. But the longer the liquor is kept in contact with the gas the more highly does it become carbonated, owing (as already said) to the greater affinity which CO_2 has for ammonia and other alkalies than SH_2 has; whereby the sulphuretted hydrogen, which is at first absorbed in the scrubbers simultaneously with the carbonic acid, is thereafter displaced by the latter substance.

Thus every attempt to employ gas liquor for the object proposed by Mr. Hawksley—viz., the absorbing of the sulphur impurity—failed, from a neglect of the real facts of the case. In 1870, after these successive attempts had been tried, the gas referees instituted a series of testings in some of the principal London gas works "for ascertaining the effect of scrubbers upon the quantity of sulphur compounds in the gas." The following table, which gives in a condensed form the result of those testings, shows how entirely inoperative the scrubbers were upon the sulphur impurity; in the majority of cases (as will be seen) there being actually *more* sulphur in the gas when it emerged from those vessels than when it entered them:

	Increase or Decrease of Sulphur at outlet of Scrubbers. Grains.
Bow Common Works	+ 5·06
Fulham "	— ·35
St. Pancras "	+ ·10
Haggerston "	— 1·50
Blackfriars "	+ 2·25
Old Kent road "	— 4·05
Horseferry road "	+ 1·45

I may take credit to myself for having fully cleared up the *rationale* and practical effects of the action of washers and scrubbers, as well as of the other stages of purification; and I shall now show how the action of washers and scrubbers can be *regulated* relative to the absorption of CO_2 and SH_2, and bisulphide of carbon also, and the different modes of working those vessels in order to accomplish the different results which it may be desired to obtain from them.

An important improvement in gas purification has yet to be accomplished in the use of washers and scrubbers, by not merely using these vessels for the absorption of ammonia, but by also regulating their action upon the other gas impurities. I am confident that in every large gas works this regulation will ere long be universally adopted, and these vessels will be employed, relative to the absorption of CO_2 and SH_2 (or, by a wider change, for CS_2 also) in a systematic manner, with reference to and in harmony or co-operation with the working of the purifiers, so as to remove these impurities upon a uniform and regulated system, in which the washers or scrubbers and the purifiers (whether containing lime or oxide of iron) will be *combined in their action in one continuous series of operations.* In truth, what I here propose may be regarded not merely as a new mode of working washers and scrubbers, but rather as a substantially new use of those vessels.

The fundamental point in this matter is the fact that in washers and scrubbers we have a substance, or purifying material, exactly similar to and identical in character with the lime in purifiers. Formerly, from the beginning of gas purification, lime purifiers themselves (vessels specially employed to absorb SH_2 or SH_2 and CO_2 together) were worked in a haphazard or ignorant manner; therefore one need not be surprised that the action of washers and scrubbers (vessels specially employed for ammonia) upon these other impurities was equally misunderstood. But the fact that the ammoniacal liquor formed in washers and scrubbers is quite as potent and efficient as lime for absorbing CO_2 and SH_2, and is equally capable of being systematically regulated in its absorption of these impurities, suggests at once the advantage to be gained by turning this liquor to the best possible account as a purifying agent.

Lime, as employed for gas purification, is an expensive and also a dirty material; and it is acknowledged on all hands that a great point would be gained if the use of this can be minimized, still more if it can be wholly dispensed with. By my new mode of employing washers and scrubbers, not only the first but also the second of these ends can be attained. But first let me speak of the minor of these improvements, *i.e.*, the minimizing of the use of lime.

Now that the gas requires to be purified from the "sulphur compounds" which so long baffled the gas world, *some* alkaline substance is indispensable in gas works for the production (by absorbing SH_2) of an alkaline sulphide, by which material alone it is possible to extract these "sulphur compounds," *i.e.*, the sulphur in other forms than SH_2. Accordingly, since I made known how these alkaline sulphides can be produced in gas works efficiently (and indeed profitably also) for this purpose, lime has been largely employed by all the London gas companies, instead of the oxide of iron previously alone in use. But, as I have shown, before such sulphides can be efficiently produced, it is indispensable that the CO_2 be previously extracted from the gas; and for this purpose also lime, or else some other alkali, must be employed. Thus there are two separate objects for which lime (or some other alkali) must be employed, viz., (1) to extract the CO_2, and (2) to form an alkiline sulphide. By the old system, lime was employed for the absorption of all the acid or acidulous impurities (SH_2, CO_2, and CS_2) indiscriminately, and in a haphazard or unregulated, and as regards CS_2, wholly unsuccessful manner. But now that the right mode of purification is understood, the point to be accomplished is to restrict the use of lime to the one purpose of producing sulphide of calcium (for the absorption of CS_2), by making it absorb *only* the SH_2, or rather only such portion of the SH_2 as is indispensable for the production of an adequate quantity of the calcium sulphide, the remainder of the SH_2 being taken out by oxide of iron, which costs nothing.

To do this, we must find some other material for taking out the CO_2. And this can be done, not wholly, but to such an extent as to save a great deal of the lime, by employing the washers and scrubbers as mainly decarbonating vessels, viz., by retaining the liquor in the washers and returning it into the scrubbers until the portion of SH_2 originally absorbed in the liquor is expelled by the CO_2 in the gas, and the liquor is fully carbonated. It may be said, there is no advantage in this, because if the scrubber liquor be wholly employed for extracting CO_2, an extra and exactly equivalent proportion of the SH_2 will remain to be absorbed by other means. The answer to this is (1), that it is indispensable to remove the CO_2 first of all (in order that a large amount of pure alkaline sulphide may be thereafter produced for the absorption of CS_2), while the SH_2 must be kept in the gas for the conversion of the lime into calcium-sulphide, and that any more of the SH_2 than is required for this purpose can be extracted by oxide of iron, which is a costless material. (2) It is to be observed that it is impossible to employ the SH_2 in the ordinary scrubbers for the production of the indispensable alkaline sulphide, capable of absorbing the CS_2, because the CO_2 in the gas as it enters these vessels is so many times larger in quantity than the SH_2, that sulphide of ammonium cannot be formed in the scrubbers in such quantity or purity as to extract CS_2, so that the extraction of this impurity must be effected in subsequent vessels (*e.g.*, lime purifiers) wherein a large amount of alkaline sulphide can be formed.

But by working the washers or scrubbers in the manner above described, viz., devoting the ammoniacal liquor formed in them specially to the extraction of CO_2, these vessels can, to a great extent, take the place of the first set of lime purifiers under the new system, viz., the decarbonators, or those set apart for taking out the carbonic acid. In this way, obviously, there will be a great saving of lime. The washers or scrubbers, in fact, will be worked *together with* the lime purifiers, exactly as (and to a considerable degree in substitution for) the first or decarbonating set of these purifiers under my new system.

I must here advert to a peculiar action of the ordinary ammonia washers and scrubbers, in which respect they differ from lime purifiers, namely, that it is impossible to fully carbonate their contents, a portion of the liquor always remaining sulphuretted. The explanation of the difference is as follows: In lime purifiers the amount of alkaline material (*i.e.*, the lime) is a fixed quantity; and however large or however small this quantity may be, by keeping it in contact with the crude gas, the whole of it can be carbonated—the portion of the lime which is at the outset sulphuretted being gradually but quickly carbonated in consequence of the CO_2 expelling the SH_2. But in washers and scrubbers the case is somewhat different, because in these vessels the amount of alkali is *never a fixed quantity;* it is every moment increasing, owing to the water progressively absorbing more and more ammonia from the gas. And as soon as more ammonia is absorbed by the water, this fresh or momentarily unsaturated portion of the ammonia takes up CO_2 and SH_2 simultaneously and indiscriminately; and although this new and additional portion of NH_3, or rather the part of it which absorbs SH_2, is speedily carbonated in its turn, nevertheless there is always being formed another increment of NH_3, which absorbs CO_2 and SH_2 alike. In fact, as the water or liquor in the scrubbers is never retained in action until its capacity for absorbing ammonia is exhausted—as it is never *fully* saturated with NH_3—it goes on absorbing ammonia continuously, though with diminishing rapidity, all the time it is kept in the washers or scrubbers; and thus, in the way above stated, at every moment the liquor contains *some* portion of ammonia which is being saturated with SH_2 as well as with CO_2. For example, suppose these vessels at any time stopped (or the gas shut off from them), *some* portion of the liquor, although a small one, would be found sulphuretted, however long the liquor had been kept at work, *i.e.*, in contact with the CO_2 in the gas.

I draw attention to this matter because it greatly puzzled a friend of mine, a most accomplished gas engineer, who, on finding that the scrubber liquor always contained some portion of SH_2, came hastily to the conclusion that although my new system based *inter alia* on the power of CO_2 to expel SH_2 from alkaline substances, applied perfectly to lime purifiers, the said chemical action did not take effect upon gas liquor, to which material my new process is equally applied. As above shown—and as indeed might have been confidently expected from the identity in chemical character of lime and ammonia—this is entirely a mistake. The gas liquor, by being kept in contact with the crude gas, is decarbonated just as lime is, although from the circumstance that the alkaline material in washers and scrubbers is (unlike the lime in purifiers) constantly increasing, a portion of this *increment* of ammonia will be found sulphuretted unless the liquor were kept so long in action that its power of absorbing ammonia has been absolutely exhausted.

The above-described mode of working washers or scrubbers, then, will save lime in gas works where this material is employed, and where it is necessary to get rid of the sulphur in other forms than SH_2.

But a far wider change may be made in the employment of the ammonia washers and scrubbers:

1. Until recently, and in most gas works at present, the work of condensation was so imperfectly done that the gas as it entered the washers or scrubbers contained a large portion of tarry matter which had to be removed in these vessels before the gas passed into the purifiers, because the tarry matter would spoil the lime or oxide of iron. But it is not only desirable but perfectly practicable to remove the whole of the tarry matter in the condensers; and when this is done, it seems to me that a radical change might be made in the employment of the purifying apparatus, namely, *by passing the gas as it leaves the condensers directly into lime purifiers, and to use the washers or scrubbers last of all;* and then to employ the lime purifiers solely to decarbonate the gas, in such a manner as at the same to drive forward the sulphuretted hydrogen into the washers or scrubbers, where it will be absorbed along with the ammonia, thus forming pure sulphide of ammonium, whereby the "sulphur" would also be extracted.

By this process the lime would be devoted simply and solely to decarbonating the gas, and the spent lime will come out of the purifiers wholly in the inodorous state of carbonate. Accordingly, this mode of employing lime can be practised in any gasworks without creating the slightest nuisance.

2. Or, lime and purifiers might be wholly dispensed with, by revivifying a portion of the gas liquor, and employing it in washers or scrubbers, where it would act exactly the same as lime in purifiers; and thus the entire work of purification from beginning to end would be carried on in *closed vessels, occasioning no nuisance either to the workpeople or the public.* Moreover, there would be *a great, indeed entire, saving of labor*, because washers and scrubbers are self-acting apparatus, whereas the expense of filling and emptying purifiers is a heavy item, costing about as much as the material employed in them.—*Engineering.*

PHOTO-MEZZOTINT ENGRAVING.

IN the production of an engraved copperplate for yielding impressions in the copperplate printing press three or four methods have long been employed, each of these being especially applicable to certain classes of work. But since the discovery of photography, and the application of that art-science to the art of the copperplate engraver, numerous ramifications have been initiated, the result being that it is possible to produce a plate by a far greater variety of photo-chemical means and processes than at a former period could have been imagined by the most sanguine idealist.

As the process of which we are about to describe partakes of the nature of mezzotint engraving, we preface such description by some observations on this method. When a copperplate has its surface smoothly polished, it is obvious that when inked and subsequently rubbed with a clean pad of cloth the ink will all be removed. On the other hand, if the surface be made granular, it is equally obvious that the ink cannot be removed from the surface by friction, and that on the application of sufficient pressure the ink will be transferred to a sheet of paper rolled in contact with the surface. These two facts form the basis upon which the system of mezzotint engraving is constructed. If upon a finely granulated surface of metal—and it matters little whether the metal be copper, brass, zinc, or iron—certain portions be made shallower by scraping, or perfectly smooth by scraping followed by burnishing, the lights and shadows in the impression obtained therefrom will be in the precise ratio of the work put upon the surface, a touch of the burnisher upon the surface corresponding with a touch of illumination upon the otherwise dark impression obtained from it. Suppose, then, that an engraving of a portrait were required by the ordinary mezzotint process: it is only necessary that upon a well-roughened surface a drawing of the subject be made and all the middle tints slightly scraped, and the high lights more thoroughly scraped and burnished, to produce a plate in which, as directed by the tool of the artist, certain parts will print black, others white, and others again in a corresponding degree between these extremes.

Acknowledging here by a passing word all that has been done by Mr. Woodbury in connection with the preparation of engraved plates, we shall now indicate a method quite different from that of Mr. Woodbury, and by which we have succeeded in obtaining good results.

Upon a polished steel plate spread a thin coating of—

Saturated solution of bichromate of ammonia	5 drachms.
Honey	3 "
Albumen	3 "
Water	1½ pints.

Let this be dried by gentle heat, and then, when thoroughly dry, expose to light under a transparency. Now remove the plate to a place in which the air is moist. We at one time considered that a cellar was necessary for this purpose; but, after repeated trials, we find that the atmosphere in an ordinary room contains moisture sufficient to act upon the surface of the picture which has been printed in a manner indicated. The preparation of which the formula is given above is slightly deliquescent, and very soon after it has become quite dry by the application of heat it attracts so much moisture from the atmosphere as to become more or less tacky. But the exposure to light has the tendency of hardening the film; so that the tackiness produced is in the inverse ratio of the luminous action. A large camel's hair brush is now charged with a mixture of the two finest kinds of emery powder, and applied with a circular kind of whisking motion all over the surface. As those portions of the plate on which the light did not act are the first to become tacky the emery powder will first adhere to them, and we find that the coarsest particles attach themselves to those parts of the picture that are in deepest shadow. The exposure to light ought to be such that every portion of the surface, with the exception of the extreme high lights, becomes in a condition to "take" the powder. If the image be slow in becoming developed under this pulverulent treatment, then the moisture in the atmosphere should be slightly increased. The mere allowing of the picture to stand for five minutes longer frequently answers every purpose; the moistening of the air by artificial means will answer the same purpose without any delay. This film is so susceptible to the influence of moisture that the operator should take great care lest his damp breath impinge on the picture, as the moisture caused by such a local application might result in a local predominance of the power which attaches itself in obedience to hygrometric law.

We may here observe that a quarter of an hour's experimenting will at this stage enable the practitioner to learn more—provided he uses his eyes and his judgment—than we could teach him by writing at far greater length than would here be expedient.

Assuming, then, that the picture has been developed, a polished plate of metal, softer than that upon which the picture is formed, must have been procured and laid down upon the other, face to face. They are passed between a pair of rollers screwed so well together as to insure the setting off on to, or indentation of the emery-powder image into, the polished plate of metal. This latter plate is now precisely similar to the one produced by the mezzotint engraver.

An impression having been obtained by an ordinary copperplate process, the manipulator (whom we must now designate the "artist," seeing that art-feeling and knowledge must be brought into play), having the proof and the plate both before him, applies a small burnisher with a curved point to the various portions of the picture requiring lightening. After having completed this work to the best of his judgment, a second proof is obtained, and, if nessessary, a second series of the alterations are made upon the plate, until it is finally found that it yields an impression quite equal to the requirements of the subject. This being the case, it only remains to hand the plate over to the printer, who will produce the impressions equal in every respect to the first proof.

The method we have here pointed out is no shadowy or mere theoretical one, for we have most carefully carried it out in practice; and but for the inconvenience of issuing a copperplate engraving with a journal printed in "letterpress," we might have illustrated this article by a specimen picture prepared by the process described.—*British Journal of Photography.*

DRY ROT IN WOOD.

THE best preservative against dry rot is said to be the following of Mr. Schwartze, who made millions by it, and by whose recent death the secret was revealed: 1 part oil of cassia, 1 part woodtar, and 1 part common train oil; apply three coats on the reverse sides and on the ends of planks, floors, etc. In all probability oil of cassia played the chief rôle as preservative.

THE HISTORY OF THE ART OF COACH-BUILDING.*

By G. A. THRUPP, Esq.

AMERICAN CARRIAGES.

THE carriages of America are so different from our own, and from those of Europe, that they require special attention. It is possible that their style may influence in an important degree the carriages of future ages. We see in them, primarily, "lightness." That lightness in their larger carriages is carried to excess, most coachbuilders will agree. We are supported in this view by the fact that for some years these, such as landaus, broughams, and coaches, have been materially modified by European types. The Americans have adopted some of the shapes of Europe, and the mode of constructing the under carriages, retaining their own methods of making the pole and splinters, or whipple trees, as giving greater freedom to the horses. I think this principle of allowing the horse greater scope for exertion is particularly worth the attention of coachbuilders. The manner in which our horses are confined by tight heavy strapping and traces, by tight pole chains, by bearing reins, and the indiscriminate use of blinkers to the bridles, has been much overdone in England. If a horse with a heavy load, and driven fast over slippery roads, should stumble, it is most difficult for him to recover himself—he falls, and is sometimes pushed along by the impetus of the carriage, and is more or less injured in his limbs or nerves by the accident, whilst it is difficult for him to rise again until the harness is unstrapped and the carriage is removed from above him. We also harness our horses too closely to their work in the two-wheeled carriages. We have thought only of the ease of turning and moving the whole vehicle in crowded or narrow ways, without observing the advantage of the long shafts over short shafts. If the shafts are considered as levers, by which the horse supports and moves the weight behind him in a two-wheeled cart, it will be at once obvious, that although (whilst those levers are parallel with the road) it does not so much signify whether they are long or short; yet the moment they point upwards, and especially when they point downwards, the difference between long and short levers is felt severely by the horse. We can all of us lift a weight or support a weight more easily with a long lever than with a short one, and it is the same with a horse. Those who have traveled abroad must have noticed the great weights placed upon two-wheeled carts in France and Belgium, and the greater comparative distance at which the horse is placed from the wheels, and yet how little the horse is distressed. He manages his load more easily because he does not feel the weight so heavily upon his back. Many drivers in England seem to have observed this, and try to ease the horse and lessen his chance of stumbling by tipping the shafts up in front, but in this way the horse is made to feel a pressure on the under part of the body which is neither natural nor healthy. I think, therefore, that in future years the growth of public opinion will be in favor of longer shafts and poles. This will also tend to preserve good carriages from the damage they at present suffer from the heat of the horses, and the quantity of mud which is thrown by their heels upon the front of the vehicle. The reins will of course have to be longer, but this cannot be of much consequence; the driver of a brougham is further from the horse than the driver of a mail phaeton, but we do not consider that the brougham is more difficult to drive than the mail phaeton on that account.

Another fashion prevalent in this country, and some others, may prove, in the opinion of the drivers of the future, to be a fallacy; I mean the supposed necessity for the driver to sit nearly upright, which necessitates a deep boot and a clumsy, thick coachman's cushion. In America, Russia, and in parts of Germany, the driver sits low, but places his feet against a bar in front of the footboard, which in their carriages is longer than in ours. I have seen four horses driven very well and easily in a low landau, and very powerful, fast-trotting, pulling horses held in with apparent ease. It has seemed to me that our coachman are often in danger of being pulled over by their horses; and certainly, when an accident happens in a collison, they are easily thrown from their boxes. They do not have the purchase and security that the Russian drivers especially seem to possess.

Perhaps we shall learn from the American carriages a few useful hints in this respect.

The American carriage, called, I believe, a "rockaway," has a projection over the driver's seat, to shield him from sun and rain. Some of the Asiatic carriages have an awning for the same purpose. In Italy traveling carriages often had a hood over the driver. In instances where the master of the household likes to drive his own family carriage, it would certainly add to his comfort, and that of any one sitting by him, to have some useful addition of this nature.

The greatest novelty introduced by the Americans of the United States is the light wagon, called also "buggy," a name first given in England, a hundred years ago, to a light two-wheeled cart carrying one person only, and which we call a "sulky." These American wagons were modelled from the old German wagon, but they have been so much improved as to be scarcely recognized. The distinctive feature of the German wagon was a light shallow tray, suspended above a slight perch carriage on two grasshopper springs, placed horizontally and parallel with and above the front and hind axletree; on the tray one or two seats were placed, the whole was light and inexpensive, and well adapted to a new rough country without good roads. These wagons may still be found in Germany and Switzerland. They were doubtless formed as a development of the V-shaped agricultural wagon already described in the second lecture.

The American ingenuity was lavished upon these wagons, and they have arrived at a marvel of perfection in lightness; the two grasshopper springs have been replaced with two elliptical springs. The perch, axletrees, and carriage timber, have been reduced to thin sticks. The four wheels are made so slender as to resemble a spider's web: in their construction of the wheels the principle of the patent rim used in England in 1790 has been adopted. Instead of five, six, or seven felloes to each wheel, there are only two, of oak or of hickory wood, bent to the shape by steam. The iron work of the American buggy is very slender, and yet composed of many pieces, and, in order to reduce the cost, these pieces of iron are mostly cast, not forged, of a sort of iron less brittle than our cast iron. The bodies are of light work, like what we call cabinet work. The weight of the whole wagon is so small that one man can lift it upon its wheels again if accidentally upset, and two persons of ordinary strength can raise it easily from the ground. The four wheels are of nearly the same height, and the body is suspended centrally between them. There are no futchels; the shafts or pole are attached to the front axletree bed, and the front of the pole is carried by the horses just as they also carry the shafts; the splinter-bar and whipple-trees are attached to the pole on swivels. Some are made without hoods and some with hoods. The hoods are made so that the leather of the sides can be taken off and rolled up, and the back leather removed, rolled, or fixed at the bottom, a few inches away from the back, the roof remaining as a sunshade. The leather work is very thin and of beautifully supple enamelled leather.

*From a lecture before the Society of Arts, London.

SUPERIOR INTELLIGENCE OF AMERICAN CARRIAGE WORKMEN.

The perfection to which the American buggy or wagon has been carried, and every part likely to give way carefully strengthened, is marvellous. Those made by the best builders will last a long time without repair. The whole is so slender and elastic that it "gives"—to use a trade term—and recovers itself at any obstacle. The defect in English eyes of these carriages consists in the difficulty of getting in or out by reason of the height of the front wheel, and its proximity to the hind wheel—it is often necessary to partly lock round the wheel to allow of easy entrance. There is also a tremulous motion on a hard road which is not always agreeable. It is not surprising, however, that with the great advantages of extreme lightness, ease, and durability, and with lofty wheels, the American wagons travel with facility over very rough roads, so that there is a great demand for them in our colonies. It must be remembered that the price is small, less than the price of our gigs and four-wheeled dog-carts. This cheapness is attained by making large numbers to the same pattern, by using cast iron clips and couplings and stays, by the use of machinery in sawing and shaping, grooving and mortising, the timbers, and by the educated dexterity of the American workman, always ready to adopt any improvement. An educated man will make a nimble workman, just as an educated man learns his drill from the military instructor more quickly than a clown. And an educated man finds out the value of machinery and desires to use and improve it. Instead of fearing its rivalry, he welcomes it; he remembers that all tools, even the saw and the hammer, are machines, and that the hand—the human hand—that guides those tools, is but a perfect machine obeying the guidance of the brain more quickly and in a more varied manner than any man-made machine. The American workman therefore uses machines more and more.

In England, machinery for wood-shaping is used at Derby, Newcastle, Nottingham, Worcester, and other towns; and in Paris some beautiful machinery is at work in coach factories. In London, I believe, it is chiefly confined to patent-wheel factories. We use also a few steam-driven saws, some paint-grinding mills worked by hand, and drilling and punching machines. But until the use of machinery is adopted more generally in London, it is probable that the trade of building carriages for export will drift more and more to the provinces and to the Continent. The saving of machinery in omnibus and cab building would be great, because the patterns vary so little, and all other parts of one carriage could correspond with another, and counterchange when repairs were needed.

The coachbuilders of the future will look to steam and hand machinery as their great assistance in cheapening the cost of first-rate carriages, in multiplying them for the probable increased demand, and also to build carriages more speedily. It now takes from two to three months in building a brougham, of which at least five weeks is consumed simply in the wood and iron work, a period which by machinery might easily be shortened.

With regard to the American wagons, they are so completely a carriage of themselves, there is so little to work upon, that we do not look for great beauty: that each of its parts should be gracefully shaped must be sufficient. The shape is conventional, there is no great opportunity for style.

The larger carriages of America, however, in which there is plenty of room for style and grace, are, to an European eye, deficient in both. The extremely ugly straight and abrupt lines of the upper parts of the bodies, the wriggling, uncomfortable sweeps of the lower parts, the want of proportion, the scanty room for the legs of the passengers, must astonish all who have seen the carriages of other countries. American wheeled carriages seem to say, "We are made for lightness, and nothing else." On the sledges, however, grace, comfort, and elegance seem to have been lavished, and, to use an American term, "pleasing lines" and sweeps abound in the sleigh.

In all carriages the proportions of the different parts, to please permanently, must harmonize. If at one time the fashion of the day is for deep quarters, and deep rockers, and very shallow panels, it is certain that the eye of the man of taste will sooner or later correct this, and return to the proper depths of each. If at one time the wheels are too high, a Hobson will arise and cut them lower. If the curves grow too rampant, and the scrolls and foliage too abundant, a more cultivated taste will modify all this sooner or later. It is certain that our American cousins will alter the shapes of their larger carriages, and continue to improve them. In Australia—where the admiration for American and English carriages is nearly equal—there are native carriages built which, we are told, combine the lightness and durability of American carriages with the grace and comfort of English carriages. It may not be so yet, but it is cheering, at any rate, to hear of the attempt, and all true lovers of the craft must rejoice if it succeeds.

In America the principles of draught have been carefully considered and discussed in a magazine specially published for coachmakers, and which magazine does the greatest credit to its able editor, Mr. Ezra N. Stratton, of New York; it is beautifully illustrated, and is full of information for all branches of the craft. There is another magazine in the same city called the "Hub," edited by Mr. George Houghton, who visited Europe to see the recent display of carriages at the Exhibition at Vienna and London in 1873.

PRINCIPLES OF DRAUGHT.

The principles of draught are in these works first set out with reference to the sledge. We are told that, from long experience, it is found that if the traces are attached to the sledge so high that the trace is horizontal or parallel with the ground, and the sledge meets with any obstacle in a rough track, that the runners will bite into the obstruction, so as almost to stop the team, but that if the traces are fastened lower, so as to form a straight line from the horse's collar to the hind end of the runners of the sledge, that they will lift, as it were, at the obstacle, and glide easily over it. This theory appears quite correct. It is more readily discovered in a sledge than in a carriage upon wheels, but the principle is the same in each. Again, if the runners project in advance of the sledge, it follows easier than if they begin to turn upwards beneath the weight of the sledge. This in wheel carriages is the same as if the weight of the carriage is mostly on the low front wheel, instead of upon the higher hind wheels.

In the New York magazine we are asked, "Why will a team haul a load on a vehicle of four wheels easier than the same load upon two wheels?" and "Why will a team haul a load in a circle, which they cannot move straightforward?" The obvious answer is, that the same load presses on the ground in two places heavier than it does upon four places, and secondly, that, when moving in a circle, the obstacles are less felt by the inner wheels than by the outer. But the magazine gives further ingenious reasons. When a load is resting upon a two-wheeled vehicle, it is very seldom placed so as to balance just right. If correct for level ground, as soon as it ascends a hill, or descends, the balance is unsettled. When the wheels come to a hole, or a big stone, all the load must be raised with two wheels and only half when on four wheels. Again, an uneven road twists the horse that is between the shafts from side to side, when the load is on two wheels, more than when, on four wheels, the fore carriage rotates on the perch-box. Again, on an incline the four-wheeler moves by its own gravity, whilst the two-wheel gives additional weight at once on the horse's back. To the second question the magazine writer remarks that an experienced driver takes his load up hill zigzag, and not straight, and what is lost in time is gained in power. On the question of the height of the splinter-bar and whipple-trees, he gives his experience of twenty years that they should be, as a rule, a foot below the point of traction at the horse's collar. He explains the advantage of splinters (like our leading-bars) for all the horses of a team, and not only the leaders, to be this—that if one horse is lazy, then the others draw their bars forward, and, consequently, his bar going back brings his traces tight again.

With reference to the method of attaching the horses close to their work in England, and some distance from their work on the Continent, I wish to have it understood that I do not consider the continental custom absolutely superior to the English custom, but I consider we might adopt a middle course with great advantage to the horses and passengers. It is certain that on the Continent the horses have, in many instances, their traces too long, as it is that we have them often too short.

There has been much controversy about the difference in the length of the front and hind axletrees. It has been usual to make no greater difference than will allow the higher wheel to follow in the same track as the lower wheel. In France, however, it has been the practice, from the year 1846, to make the front axletree of broughams six inches shorter. The object has been to allow the front wheel to be placed nearer to the body. As the front wheel of a brougham must turn entirely in front of the body, the additional gain of three inches was very desirable. Some English coachbuilders have followed the example of the French. There is a decided gain. The eye is pleased with the proportions. The horse is eased, and upon hard roads the difference of trade is of no consequence. On the other hand, in country roads, the well-worn ruts make the running of the carriage uneasy, whilst in town the driver often forgets that the curbstones will strike the hind wheels sooner than the front wheels, and lastly more mud is thrown upon the panels. It is probable that the French style will not find favor.

In coaches built in 1750 it was customary to lower the hind part of the inside seats about two inches; by degrees this was changed to a level seat; recently the seat has been again lowered behind, and the back squabs made more upright than formerly. The height of the top of the cushion to the bottom of the body has varied during the same period from 14 to 18 inches. These slight changes belong more to the taste of the individual who uses the carriage. It is useless to lay down any general rule on these subjects.

If carriages had always to move along perfectly smooth roads, such as a tramway of wood, iron, or stone, the use of wheels in overcoming friction would be their sole utility, and the height of the wheels would be of small consequence. But as carriages are drawn along roads with loose stones and uneven surfaces, wheels are further useful in mounting over these obstacles, and it is plain that a high wheel does this more easily than a low wheel. To demonstrate this, let us suppose a shallow ditch or gulley of a foot wide and 2 inches deep, a wheel 2 feet high would sink into this and touch the bottom, but a wheel 3 ft. high would only sink an inch, and a wheel 4 ft. 6 in. high would sink only half an inch, on account of their greater diameters. Consequently, whilst the large wheel would have to be lifted by force of pulling only half an inch, the smallest wheel must be lifted two inches, and with the wheels must also be lifted a portion of the load of the entire carriage. Again, the long spoke acts as a longer lever, the point of draught being the axle, which is higher from the ground in the higher wheel, and again assists in overcoming the obstacle, as the angle of incidence is so much less.

That the leverage power of a high wheel is very great, we need only consider the advantages gained by a large wheel in locomotives and in bicycles. In practice, however, we find wheels from 4 ft. to 5 ft. sufficient for large carriages; from 3 ft. for ordinary vehicles.

The present method of constructing all wheels which have to carry considerable weight will doubtless continue to prevail. The timbers of which they are composed, viz., elm for the stocks, ash and hickory for the rims, and oak or acacia for the spokes in Europe and America, have been found the best for many years. Wheels of the present make must also be dished. The tendency of a wheel is always to become upright, and when it so becomes by the gradual hammering out of the tire to a greater length, and the gradual sinking of the spokes further into the nave and rim by wear and tear, then the wheel goes to pieces. If any one will watch the manner in which the materials of a mop become straight as it is twirled round, he will understand that the same centrifugal force compels wheels to become upright. Secondly, as a wheel runs along a road, it is forced from side to side by the uneven surface, the uneven draught of the horses, and the rapid motion, which latter, frequently causes the wheel to jump over the road instead of pressing equally over all its circumference. Then we dish our wheels not only to keep the tire tight as long as possible, but also to resist the lateral thrust, which in a perfectly upright wheel would soon force the spokes out of the naves. There is one exception to this rule in the American spider wheel; in this the spokes are not larger than a man's finger, and, being of elastic wood, bend like a reed under the lateral thrust, and recovering themselves again will endure, whilst the unbending oaken spoke would be unrooted.

The late Lord Palmerston, whose vigorous common sense grappled many a problem which would be supposed quite out of his line, was fond of talking about carriages. He considered that wheels should have the spokes dished, but that the arm of an axletree should be nearly straight, so that the outside rim of the wheel should be upright; and would illustrate the soundness of his views by quoting the wheels of artillery wagons and pony phaetons. It became necessary to remind his Lordship that we pitch the arms of the axles for two reasons; first, in order to keep the box of the axle pressing against the strong shoulder instead of against the weak linch-pin; and secondly, because the wheels, when they are wider at the top of the tires than at the bottom on the road, will throw the mud away from instead of into the carriage or on the panels.

There is no absolute rule for the dish of the wheel or the pitch of the arm of an axle. Experience and custom point out to a builder what is best for different carriages and different countries. It is sufficient to say that a spoke two feet in length will last longest when not dished more than its own width in its length, and that the pitch of the axle arms, to insure, chiefly, the duration of the wheels, should not be more than will leave the spokes pointing towards the ground not upright, but narrower at the naves than at the rims by three-quarters of an inch if the spokes are two feet long. This rule is simply for the duration of the wheel as long as possible, without reference to any other consideration, which the coachbuilder, however, may find over-rule what I have said. If the axles of a carriage are rather stronger than is necessary—having regard to their length between the shoulders and the weight they have to carry—it will be found to have a considerable influence upon the carriage, which will follow more steadily and quietly for the additional strength.

SPRINGS.

I do not propose to enter in this series of lectures at any length upon the subject of springs. I think we are far from having attained perfection either in the manufacture or shape of springs for carriages.

It may have been remarked that the first springs were all elbow springs, placed in different positions, however, for different carriages. A double elbow or horizontal spring of a length of four feet seems to give the most easy play of any shape, and, if made nearly straight at first, wears little in the course of time, if compared with the elliptical shape.

In perch carriages we have abandoned the nearly upright spring for the C spring, chiefly because the C spring is of a more elegant shape, and also resists wear better than the elbow or whip spring, which was found to break away from its supports.

In elliptical springs, the action of the steel plates is precisely contrary to the action in the C spring; in both, the back plates is similar in shape, but the shorter plates in the C spring are on the inner side of the curve, and in the elliptical they are on the outer side of the curve. A careful consideration of the effects of this variation may lead to a new combination which will be more satisfactory in its results. The elliptical springs made by Hobson were doubly compassed, and the same shape may be seen on some of the public omnibuses. A carriage may be hung to be very easy by using double horizontal springs, one under the other. At the Exhibition at Brussels, this year, the most easy hand ambulances on wheels were constructed in this manner.

In one elliptical spring you do not have the advantage of two horizontal springs, because the ends are in the elliptical spring united, and, if a coupling is substituted at the hind end, it is found in practice difficult to keep it upright.

Mr. Adams, in his work on "Pleasure Carriages," considers it a mistake to hollow out each steel plate of a spring. I am quite of his opinion that this process of hammering leaves the inner surface of a steel plate very uneven, thereby harboring moisture and dirt, and rendering the plate liable to fracture. I should recommend, on the contrary, that each plate should be ground or filed quite smooth on both sides. If careful tempering were generally the rule among coachbuilders, I am convinced that there would be fewer broken springs, and less complaint of rust accumulating between the plates.

ANCIENT AND EXTINCT BRITISH QUADRUPEDS.

By A. LEITH ADAMS, M.D., F.R.S.

(Continued from SUPPLEMENT No. 73.)

Allowing, therefore, for influences before referred to, we may assume that the naked skin and other differences observable in the Asiatic Elephant may be due to conditions under which the animal had lived for long ages; indeed, there appears to be a growing belief among naturalists that the Mammoth might have been the progenitor of the Elephant of Asia. In the case of the Ancient Elephant there is also an agreement, though less marked, in its teeth and bones with those of the African Elephant; but we must wait for further discoveries in the soils and caverns of Southern Europe and Asia before more exact relationships between the living and extinct species can be determined.

The Rhinoceroses that inhabited Britain possessed characters which in the opinion of many naturalists warrant their division into two or three species, all of which carried two horns, like the animals now living in Sumatra and Africa, as distinguished from other species.

The Tichorhine Two-horned Rhinoceros—so named from having a bony septum to its nose—was plentifully distributed over England after the glacial period. It is the same animal which the Russian naturalist Pallas found frozen and entire, in 1771, in the sands of the river Viloui, in Siberia. The body was clad in long shaggy hair, and the flesh and skin were for the most part preserved, from constantly lying in frozen soil—how long, who is to say? At all events, no native traditions speak of the animal. Its remains (chiefly teeth) have turned up in about sixty different localities in England, and are usually associated, as in Siberia, with remains of the equally hirsute Mammoth. Its nearest living ally is the African or Two-horned Rhinoceros, which stands nearly five feet in height, with a length of eleven feet. To judge by the measurements of the individual discovered by Pallas, the above is a somewhat smaller animal than the extinct Tichorhine species.

Another fossil species (or variety, as some consider it) has been named the Leptorhine Two-horned Rhinoceros, and is distinguished from the last-named by a more slender body, as evidenced by its bones and teeth. The third form, named the Megarhine Two-horned Rhinoceros, is distinguished by the presence of incisive teeth. The second was not nearly so plentiful as the first, whilst the third has only been met with on a few occasions in deep river deposits, thus indicating its existence before the glacial epoch. Altogether, up to the present time, remains of rhinoceroses have been discovered in no less than eighty different localities in England, whilst not a trace of the genus has been hitherto met with either in Scotland or in Ireland.

The Wild Hog was an ancient tenant of British soil, and maintained its footing as long as there were forests to give it shelter and its enemy—man—allowed it to exist. It still haunts the least civilized parts of Europe and Asia, and, by its accommodating disposition, can subsist where other herbivorous quadrupeds would perish.

It seems to have been plentiful in Great Britain, and the Boar, as a rule, was larger, and had the canines and molars more highly developed, than is usual with individuals of the species nowadays. Remains have been found associated with those of almost all the large extinct mammals, both in caverns and in river deposits. Its skull, battered in by either stone or metal ax, like those of the Long-fronted Ox, is often met with in the bogs and lake bottoms in Ireland, where large specimens have been found. It ceased to be a wild animal in that country after the beginning of the seventeenth century, but was very common in the twelfth century, according to Giraldus, who remarks: "In no part of the world have I seen such abundance of boars and forest hogs; they are, however, small and misshapen and wary."*

A Horse about the size of a Galloway seems to have been very common on British soil after the glacial period; indeed, single teeth, found in conjunction with remains of the Mammoth, Hippopotamus, and Rhinoceros, indicate an animal between fourteen and fifteen hands high, but the sizes of the teeth are no certain indication of the height of their owners. No doubt there were both large and small races, but, taking the bones into consideration, it may be safely surmised that the majority were about the dimensions above stated. The skulls indicate what horse dealers would designate a "fiddle head," but the limb bones imply that the owners combined strength with agility. The Horse was a native of Ireland in the days of the Mammoth and Reindeer, with remains of which it has been found in the lately excavated cave of Shandon. The extinction of this animal appears to have taken place long before any record of its existence was made. Some idea of the numbers of this ancient British Horse may be gathered from the fact that its remains have been recognized in no less than fifty different situations in England alone, and in northern, central, and southern Ireland; whilst, strange to say, it has not been identified in any deposits north of the Tweed. In fact, the Mammoth and Reindeer appear to have been the only large mammals which at that time frequented Scotland, where the climate was doubtless inimical to the habits and requirements of other species.

The Beaver was not uncommon in the rivers of Wales towards the close of the twelfth century, according to the Welsh author, Giraldus Cambrensis. It was also, according to historians, a native of Scotland and England in the fifteenth century; but Giraldus asserts that it was not found in his time in Ireland, where up to the present day not a trace of its existence has been discovered. The bones of Beaver, Hare, Red Deer, Roebuck, Ox, Brown Bear, Wolf, and Boar have been dug up in peat-bogs; moreover, it lingered on to historical times, and was finally extirpated by man. A few are still to be found in the more remote and sequestered river-tributaries of Central and Eastern Europe,† and the species still flourishes in Canada in spite of trappers and the Hudson's Bay Company.

Along with this Beaver there lived in pre-glacial times a gigantic species to which the name of Cuvier's Gigantic Beaver has been given. This species, however, did not survive the glacial period, and ought not properly to be included with the quadrupeds now under consideration. The connection, however, between the two shows that the smaller and more recent species survived the intense cold of the glacial epoch, possibly by migrating during its continuance to Southern Europe. The comparison in size between these two Beavers, at one time contemporaneous, coupled with anatomical characters, seems to preclude the possibility of the larger being a more highly developed race of the smaller. Beavers' bones have been dug up in the lower brick-earths of the Thames, and under the streets of London, and there can be no doubt that at one time the Beaver built its dam on this river and its tributaries as well as on many other English, Scotch, and Welsh streams and lakes.‡

The Hare and Rabbit have pedigrees which extend back to the days of the British Elephants, Rhinoceroses, Lions, and other large quadrupeds, nor do they seem to have been of greater size then than their present representatives, although jaws and skulls of hares have been occasionally met with somewhat larger than the same parts of any living species of the genus.

The Pikas or Tailless Hares of Northern Asia were once distributed over Europe, and several portions of their skeletons have been found in cave-deposits in England, associated with remains of nearly all the large extinct mammals.

The Lemming, still plentiful in Northern Europe, and renowned for its voracious habits, had a representative in England in olden times, as proved by the discovery of its remains in several cave-deposits. The Marmots or Ground Squirrels also had a compeer, as shown by the discovery of its relics in the cave of Fisherton, near Salisbury. The Water Rat seems to have been common, also the Long and Short-tailed Field Mice and the Common House Mouse.

The Large Horseshoe Bat and the Noctule or Great Bat, both still natives of the British Islands, have left their bones in caves; but, considering that they live in these situations and hide in crevices and holes, it is possible that the bones of recent individuals may get mingled with those of fossil animals. The same may be said of the Mole, Common Shrew and Hedgehog; at the same time there is every probability that these animals were contemporary in many cases with the larger quadrupeds, with whose remains their bones have been found mingled.

The last of the mammals to arrive on the British Islands after the glacial period may or may not have been Man. It is not likely, however, that he would have pushed northwards in a land destitute of the animal food on which he must have depended for his existence; it is probable, therefore, that the large herbivorous quadrupeds at all events preceded him. It is clear, moreover, that he lived on the same area with them, as proven by the discovery of his flint implements in conjunction with their remains in caves and peat-bogs. In Brixham Cavern flint instruments of the chase, comprising arrow and spear heads, axes and knives of stone, have been found mingled with the broken bones and teeth of the Bear, Lion, Great Horned Deer, Reindeer, Red Deer, Roebuck, Wild Horse, Elephant, and Rhinoceros. In Kent's Cavern, at Torquay, where the Fauna were more numerous, the same conditions have been observed. In the Gower Caves, Wokey Hole, and many other situations, the proof of man's contemporaneous existence with these extinct animals are placed beyond a doubt. It is clear, moreover, that in some instances he contributed towards, and in others succeeded in, exterminating many of the quadrupeds just mentioned; but, so far as the evidence yet extends, it is not certain that he dwelt on British soil before the glacial period.

Although stone implements, more or less rude in construction, have been discovered in Ireland and Scotland, there are no recorded instances of their having been found associated with the bones of any extinct quadrupeds; at the same time there can be little doubt that the stone arrow and spear points, wherever found, are indications of the venatorial habits of the people who fabricated them. The evidence perhaps is more circumstantial than direct; but, taking into consideration the small number of flint tools found in Ireland, with the abundance of the remains of its giant deer, it is probable that, if man existed on the island at a time when it was overrun by herds of this animal, he would have destroyed them, and their broken bones would bear traces of his violence.* But this is not the case; whilst in England the long bones have often been found in such a manner as to indicate that they were split by man for the sake of the marrow which they contained.

Such are a few of the most remarkable animals which lived and died on British soil during what may be styled a period insignificant in duration as compared with the antiquity of the æons which preceded. It is not the object of the writer to deal with the details from which the various periods have been differentiated; but, in conclusion, the reader is invited to realize the belief, founded on a study of the phenomena as deciphered by such geologists as Lyell, Ramsey, Forbes, and others, that the intervals of time, both before and after the junction and separation of the British Islands and the European Continent, embrace four distinct periods. These may be set down as follows:

Period I.—A general continental land, when the British area was a continuous portion of Western Europe.

Period II.—A submergence by which the land north of London and the Thames, and Bristol with Ireland, was reduced to an archipelago of frozen islands.

Period III.—When the sea-bed rose again, and the land equalled, if not exceeded, in extent that of the first period; the physical outline, as far as the mountains and rivers are concerned, being at first much the same as at present, only that the land rose higher above the sea, until the cold or glacial period, when the land first sank, and then was re-elevated, when the climate, still rigorous, gradually became milder, and the animals, many of which had retired to the south as the glacial period set in, again returned to their former haunts, whilst not a few became extinct.

Finally, Period IV.—After an interval, more or less lengthened, the ultimate separation of the British Islands from the European Continent, and of Ireland from England, took place, resulting in the geographical outline now delineated in a map of Europe.

Unreckoned ages are included in these changes, and no one can form even an approximate idea, according to modern computation, of their extent or duration.—*The Field.*

PHYSIOLOGY.

The Phenomena of Digestion in the Stomach.—M. C. Richet has had an opportunity of renewing the direct observations made in America many years ago by Dr. Beaumont upon the action of the stomach. A boy, suffering from an impassable constriction of the œsophagus, was operated upon by Professor Verneuil, who performed upon him the dangerous operation of gastrotomy. The operation was successful, and established a permanent opening into the stomach, through a sound placed in which the necessary food was administered to the patient. In some respects the case was particularly important, as the complete impermeability of the œsophagus prevented any admixture of saliva with the gastric juices. M. Richet found that the stay of the food in the stomach was rather variable, but it was generally from three to four hours in the case of ordinary food, such as starchy materials, fats, and meat. With milk the stomachal digestion lasted from an hour and a half to two hours; the absorption of water and alcohol was much more rapid, as no traces of them were to be found in from thirty-five to forty-five minutes. The food does not gradually disappear from the stomach, but apparently it passes through the pylorus almost, as the author says, *en bloc*. During the first three hours of digestion the volume of the mass of food is unchanged; then, within a quarter of an hour at the utmost, the whole has passed away. Hunger is not caused simply by emptiness of the stomach; the organ is generally empty in four hours after a meal, but the sense of hunger is not felt until the lapse of about six hours.

To obtain pure gastric juice, M. Richet first washed out the stomach several times with distilled water, and then gave the unfortunate boy something tasty to chew, when by a reflex action the secretion of gastric juice was pretty abundantly produced. The average acidity of the gastric juice, whether pure or mixed with food, was found to be equivalent to 1·7 grains of hydrochloric acid per 1,000 grammes of liquid. It varied from 0·5 to 3·2 grains. Wine and alcohol increase the acidity; cane sugar diminishes it. When acid or alkaline liquids are injected into the stomach, its fluids tend rapidly to resume their normal acidity, the latter being attained in about an hour. The gastric juice is more acid while digestion is going on, and the acidity increases slightly towards the end of the operation.—*Comptes Rendus de l' Acad. des Sci., March* 5, 1877.

* Topographia Hibernia.

† In Lord Clermont's "Guide to the Quadrupeds of Europe" (1850), it is stated (p. 83) that the Beaver, though in greatly reduced numbers, is still found in several rivers of the northern and central countries of Europe, such as the Danube, Rhine, and Rhone, on which last it is recorded by Crespon as occurring from Pont St. Esprit to the sea, especially among willow plantations, on which it sometimes inflicts serious injury. It is rare in Russia, except on the Dwina and Petchora, but, according to Pallas, is numerous in Siberia, Tartary, and Caucasus. As regards Siberia, see the first of the "Occasional Notes" in the present number. —ED.

‡ Fossil remains of the Beaver have been found in Berkshire (Phil. Trans. 1737, p. 119), and in Cambridgeshire (Jenyns' "British Vertebrate Animals," p. 34), in Berwickshire and in Perthshire (Neill, "Wernerian Memoirs," vol. iii., p. 207). In the ninth century the animal was known by the Welsh as "Llosdlydan" (Leges Wallicæ, iii., 11), and in Gaelic it is still termed from tradition "Losleathen." For some further particulars on the subject the reader may be referred to an article entitled "Beavers, Ancient and Modern," which appeared in *The Field* of March 22, 1873.—ED.

* The statement made by Mr. Betham in *The Field* of the 25th of December, 1875, regarding the discovery of a flint arrow-head in the rib of an Irish Elk, would, of course, at once settle the point at issue. It is not, however, by any means the only asserted instance known to the writer; but unfortunately the objects have not been preserved, whilst all so-called examples hitherto subjected to the critical inspection of comparative anatomists have been proven to be the result of injuries or disease, not inflicted or caused directly by human agency. The natural historian, therefore, is bound to be careful in accepting evidence, unless authenticated by competent authorities or the presence of the objects themselves. A rib of an Irish Elk with a hole through it is figured in Owen's "British Fossil Mammals." This may have been done by man, but the chances are that the injury was caused by the point of an antler of an antagonist.—*A. L. A.*

LESSONS IN MECHANICAL DRAWING.

By Professor C. W. MACCORD.

Second Series.—No. IX.

IT was remarked in a previous lesson that it is sometimes desirable to employ a gib and key in a link, under circumstances which would preclude the use of a set-screw at the side, for the purpose of preventing the key from backing out if it should become loose, either by wear or on account of the vibration of the mechanism. As, for instance, the link might be required to turn or be moved by a bell-crank, which might be necessarily of such limited dimensions that the set-screw could not be used. A device, which is sometimes employed in such a case, is shown in Fig. 61. It consists in forming a prolongation of the upper end of the gib, into a bolt which passes through a lug projecting from the upper end of the key; thus, when the nuts are slackened, the key can be driven down, after which they are screwed up again, gripping the lug firmly and rendering it impossible for the key to back out unless the nut above should slack loose. The same object is sometimes accomplished by prolonging the lower end of the key, and making a bolt of that prolongation, the lug being a part of the lower end of the gib. But the arrangement shown in the figure is decidedly preferable in regard to both compactness and neatness of appearance; for unless the bolt in the latter case is made parallel to the sloping side of the key, which would present a very awkward appearance, the lug must be made with a hole in it, whose length exceeds its breadth by the amount of draft due to the assumed length of the key; this not only makes the lug itself very clumsy in form, but renders it necessary to employ a large washer to cover up the hole and give the nut a fair bearing. Beside, the lug on the gib must lie in the opposite direction, that is, it must project toward the right instead of toward the left; which, in addition to the fact that in order properly to support it, there must be a pretty broad elongation of the gib, makes the whole arrangement most emphatically inferior to the one shown. All of which might possibly have been expressed more concisely and clearly by a drawing; but we have an aversion to presenting unsightly devices when it is not absolutely necessary.

In regard to the drawing of this arrangement, we begin by fixing on the diameter of the bolt, which is usually, though not necessarily, equal to the thickness of the gib, as in the figure. Having thus determined the size of the nut, we draw the center line *a b* of the bolt parallel to the sloping side of the key, at such a distance from it as to allow a little clearance for the corner of the nut—which latter, by the way, may be quite small, as the bolt has not to do work at all in proportion to its size, having merely to keep the key from working out. We next draw a line, *c d*, perpendicular to this center line, on which we find two centers, *c* and *d*, for fillets tangent to the outlines of the bolt and to the upper line of the gib-head. Thus, there is marked out a projection of the gib, equal to it in thickness; we next assume the curves of intersection shown, as the bolt is to be turned as far as *o*; it is not necessary to show the meridian outline, since this single view as it stands, clearly shows what is to be done, and it does not signify whether the curves assumed are actually followed or not. The length of the key having been determined, we draw the horizontal line *e f* as usual, *e* being the point in which the sloping side of the key, if prolonged, would cut this horizontal; then from *e* draw a perpendicular to *a b*, set off on *a b* the thickness of the lug, and draw another perpendicular as the lower outline, and put in the nuts; the top of the key is finished with the circular arc *e f*, as usual. To make all this clear, a top view is needed; but this should be made, as though we were looking, not *vertically* downward, but in a direction parallel to *a b*. Thus we shall see the hole in the lug as a true circle, and the outline of the lug itself as a part of one. To this end, we draw a center line *h i* perpendicular to *a b*, and *not* horizontally. At *f*, there is evidently a right line perpendicular to the paper in the front view, of a length equal to the thickness of the key; being the intersection of the curved top with the vertical side. This line will be seen in its true length in the top view as $f^1 k^1$; and there will evidently be another like it, corresponding to e^1 in the front view, which represents the intersection of the curved top of the key with the upper surface of the lug; the chamfering of the top of the key on the sides, as previously described, explains the appearance of the arcs in the top view, which may be assumed, as the angle of the slope is not vertical; and, indeed, were the finishers so very anxious about it, it is in fact determined when the arcs are drawn, since they show the least thickness at the crown of the curve. The slope of the key may be more abrupt when this device is used; and in the figure it is accordingly made one in twelve, thus securing a reasonable draft without making the key excessively long.

We hope it will not have escaped the notice of the critical reader, that such a contrivance as this would not be necessary, when the brasses project so far beyond the sides of the strap and stub end as they do in the figure; for even if a set-screw like those previously shown, could not have a jam nut or even a head, it might be made a little larger than it otherwise would be, and filed down square. But though this is very true, we say in explanation that our object in showing the brasses so thick, is to illustrate a feature in relation to them—not to convey the idea that this device for securing the key is to be used in connection with such thick ones. Although for that matter it might be without any impropriety; as, for instance, in the connecting rod or the coupling rod of a locomotive—when, if the key, by any chance should back out, the results would be frightful. There are many cases like this, in which it is simply impossible to make assurance too sure, or to err on the side of excessive caution. The mere slacking of a set-screw would permit the key to back entirely out, while with this arrangement that could not take place until the nut above had worked quite off the bolt, before which the thumping caused by the slackness would have called attention to the state of affairs.

The peculiarity of these brasses above alluded to is this, that the length of bearing required for the pin is obtained without making the flanges of the brasses excessively thick all over, by forming them with projections, which, when they are put together in place, constitute a hub surrounding the pin, half belonging to the butt and half to the crown brass. This hub is circular in outline, as shown in the front view, and as shown in the main top view of the rod, it does not form a square shoulder at its junction with the body of the brasses, but a liberal fillet is introduced for the sake of strength.

This form is evidently one that can be finished to good advantage in the lathe; whence, as the diameter of the hub proper is just equal to the breadth of the brass across the flanges, there results a curve of intersection, seen in the top view. This view is in this case not drawn above, over the key and bolt, as too much confusion would result from that

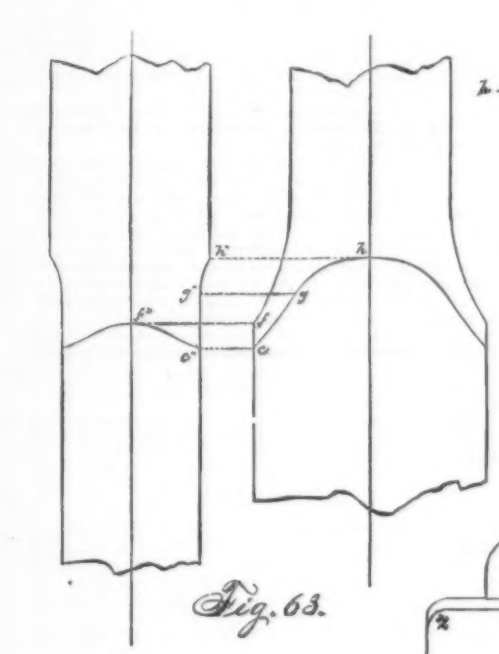


Fig. 63.

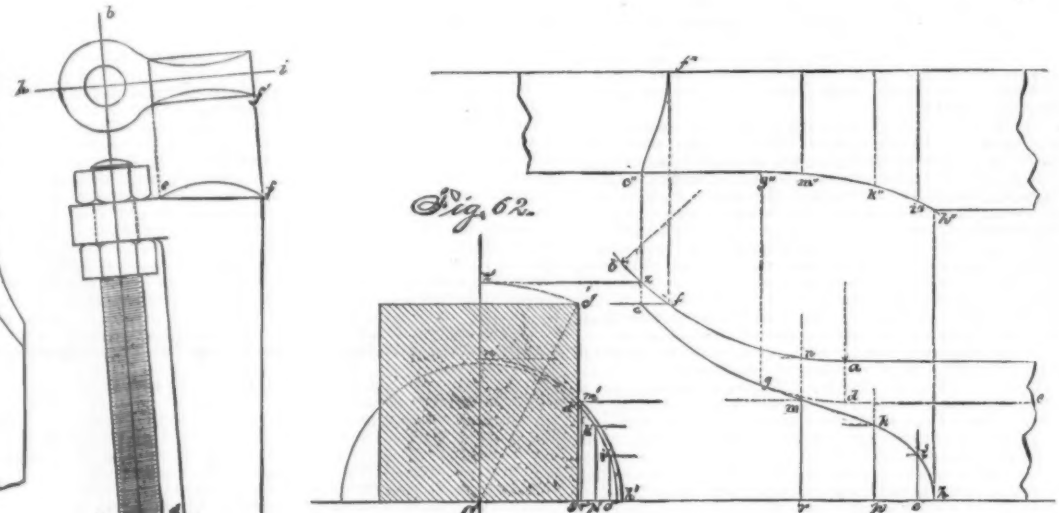


Fig. 62.

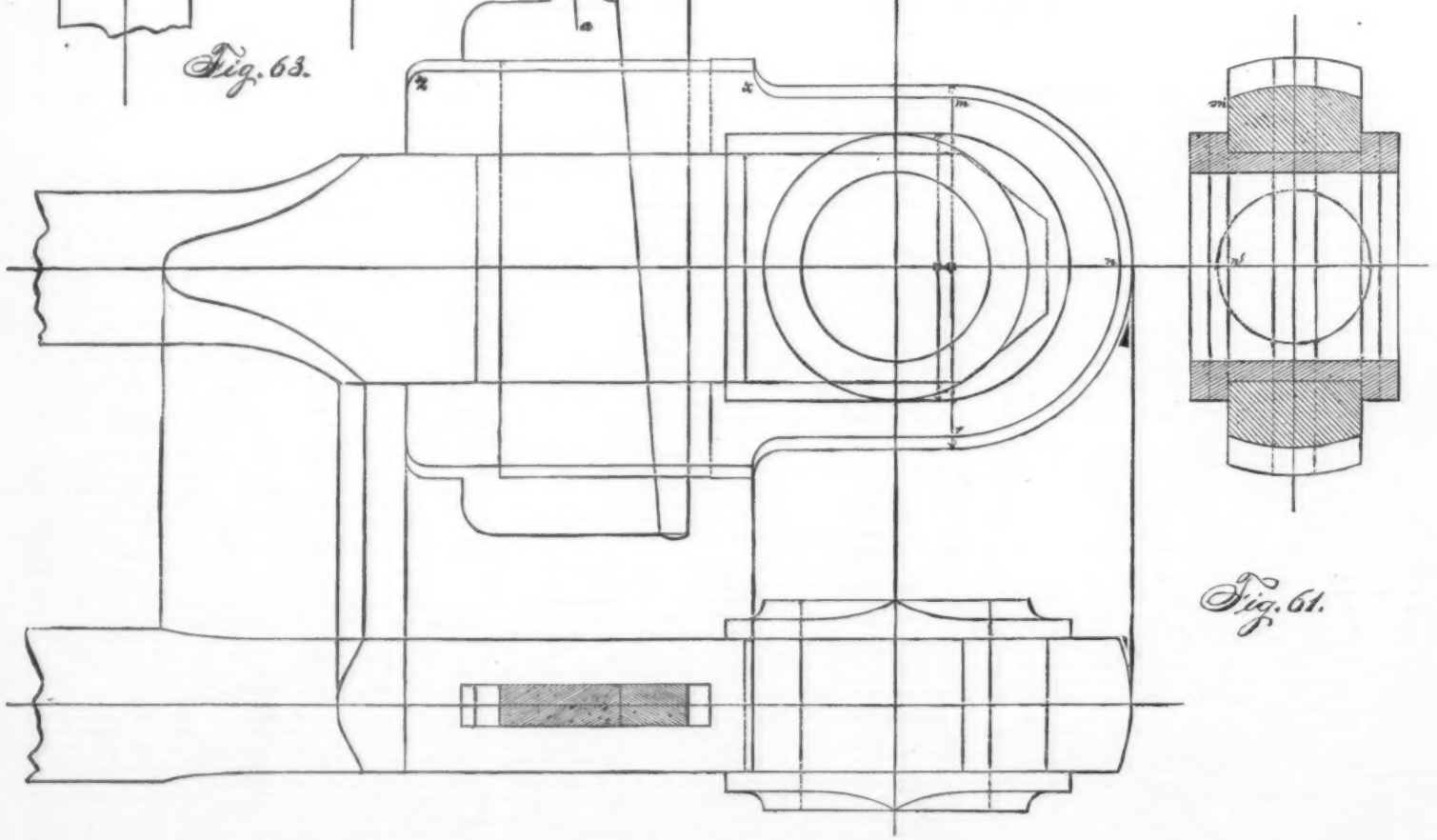


Fig. 61.

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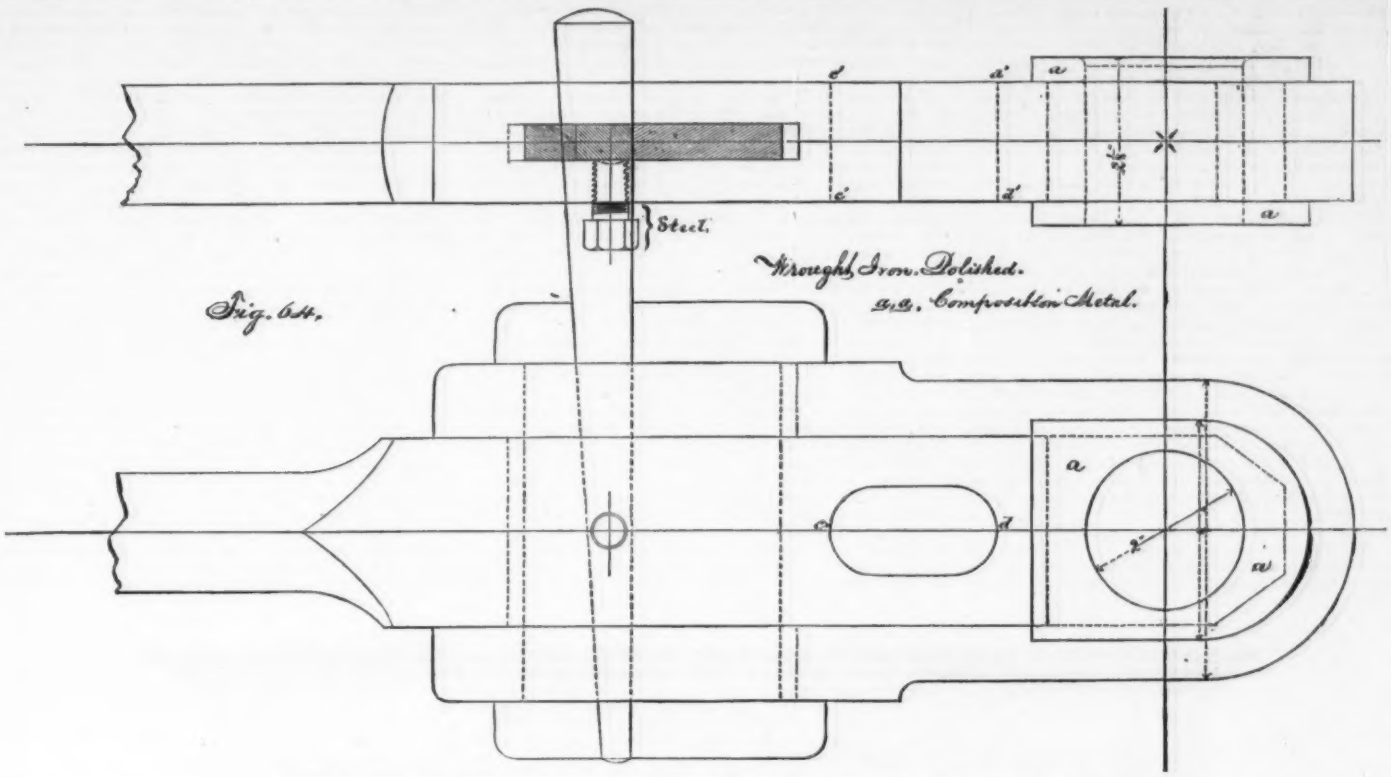

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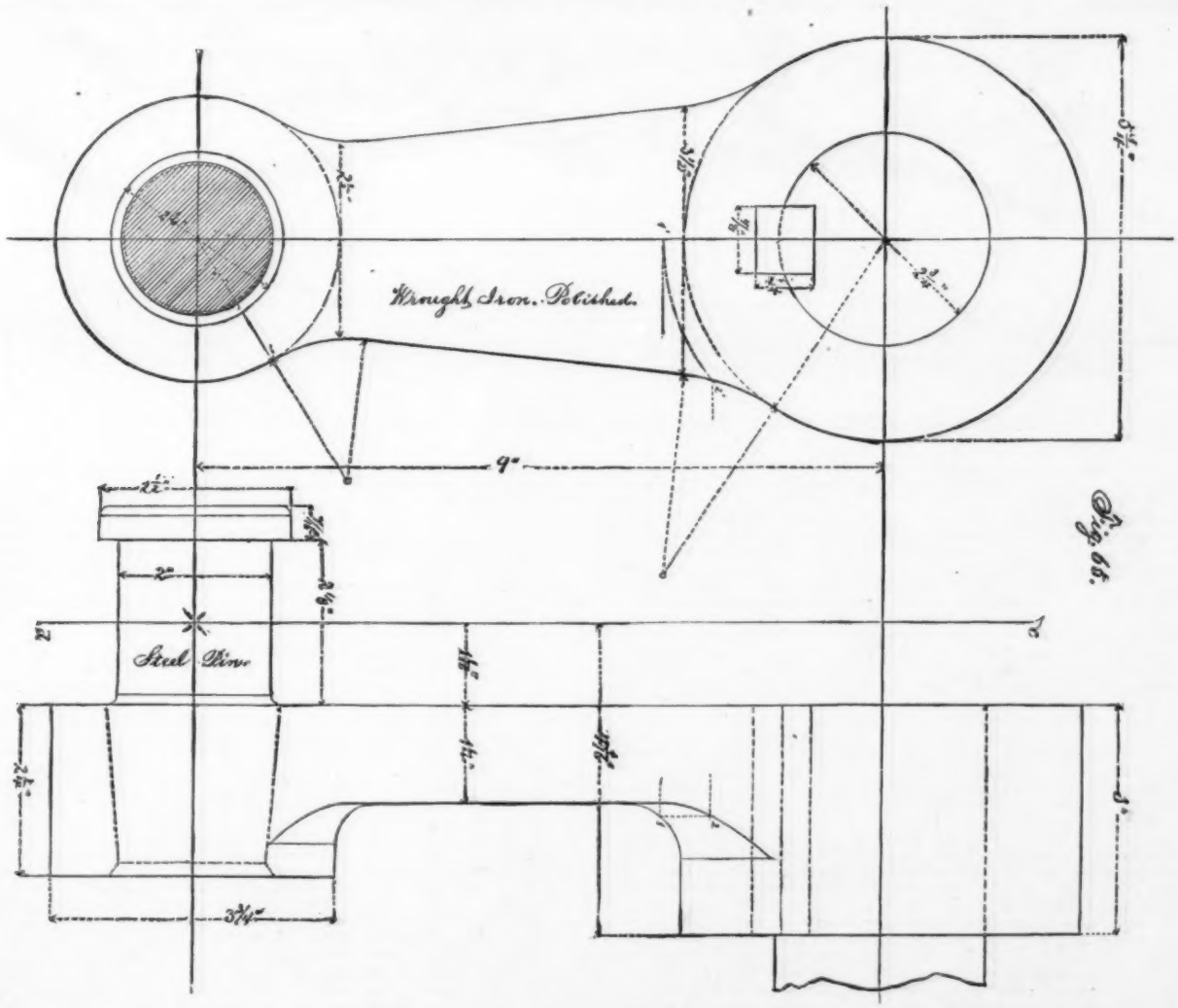
arrangement; as for the curve of intersection itself, it will at once be apparent that it is of precisely the same nature as some of those already described at length, and the student should have no difficulty in constructing it. The finish of the strap in this case is different from anything yet illustrated, and presents the advantage that the outside, including the crown, can be finished in the lathe. In order to show this more distinctly, a transverse section is added; the rod is supposed to be cut across a very little to the left of the vertical center line in the front view, so that the butt brass has a film removed, which justifies us in sectioning it in the new view, this adds much to the clearness of the drawing. This view is placed at the right of the front view, the observer looking at the latter from the right hand side; by which arrangement we see the outline of the thicker part of the strap beyond the plane of section. The gib and key are supposed to be removed, as to show them would do no good, but rather confuse matters, but the slot is dotted in, which shows that its sides cut into the upper outline a trifle below its highest point, a similar condition of things of course existing on the lower side as well. The discrepancy appears more distinctly in the side view, where it at once attracts notice, the effect being the same as if the strap had been flattened on the top and bottom. And so, in fact, it is under the hook or projection of the gib-head, which it would be hard to fit to the curved outline. This flattening also appears in the top view, the outlines of the flat part coinciding exactly with the projection of the gib-head.

We may have already stated that in the top view of a rod which is fitted with the gib and key, it makes the drawing clearer not to give an outside view of the tops of those two pieces, but to show them as if cut off by a plane just below the lower or bearing side of the hook on the gib-head; if we have not done so, this explanation will account for the appearance of the drawings, and if we have, its repetition will do no harm; as it is well for the student to bear in mind that a judicious use of simple expedients of this kind will very often serve the double purpose of abridging labor and adding to the perspicuity of the drawing.

The turning and subsequent planing of the strap also give rise to curves of intersection. The semicircular meridian outline of the crown makes that part, of course, a zone of a hemisphere; this hemisphere joins a cylinder, so that the curve of intersection, m, n, r, is a semicircle, whose radius is m^1, n^1, as determined in the end view. This semicircle is tangent to the two elements cut by the side plane of the strap from the cylinder, of which the strap is a part. Two elements are also cut by this plane from the thicker cylindrical portion of the strap through which the gib and key pass. But as these two cylinders are joined by a trumpet-shaped surface, whose outline is the fillet by which the outlines of



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the cylinders are connected, a curve will be formed at *x*, similar to those with which we are now so familiar; and at *z* we shall have another, not exactly the same, but of the same general nature, and just as easily constructed, which, therefore, we leave for the student as an exercise in the application of the principles which we have been at some pains to elucidate. Nor should he be satisfied without doing it, either.

The neck of the rod in this case also presents a condition not thus far illustrated, in that it is of a diameter greater than the thickness of the stub end.

In order to show more clearly the process of determining the curve of intersection in this case, we have introduced a diagram, Fig. 63, on a larger scale. We assume, as usual, the meridian outline of the swell of the neck, which in the figure is the circular arc *a b*. From this the curve of intersection, *c d*, is readily found, there being nothing new in this part of the operation. But it is evident that the intersection does not terminate at *d*, and that, supposing the neck of the rod to be cylindrical, that is, that the shank is turned parallel, there would be cut from this cylinder two elements, of which one only, *d e*, is shown, were we to plane the whole rod down to the thickness of the stub end. This we might do if we choose; but if we do not choose, then the question is what we shall do, in order to make a neat finish. And this question the draughtsman ought to be able to decide; it comes directly within his province, and though the mechanic will settle the matter in some way or other, if it be left to him, that is no reason why it should be, and very possibly, as tastes differ, the designer might subsequently regret it, if it were.

By comparing the top and the side views, it will be seen that the *plane* surface of the side of the stub end terminates at *g s*, after which as we go to the right this surface curves outward as shown by the line g', k'', h', in the top view; and the radius of the neck; about *C* describe a circle with this radius, and project *m* to this circle at *m'*, then *m' r'* will be the position of the line *m r* as seen in the end view, and *m''* in the top view will be at a distance from the center line equal to *Or'*.

The reader will readily see that he may, if so minded, reverse this process, and assume the curve of the side surface; and Fig. 63 is introduced to show the reason why it is better not to do so, at least without carefully considering what the result is likely to be. The stub end is of the same proportions as in Fig. 61; and the trouble is, that since we know that the strap will never come to the curve $e' f'$, in the top view, we shall be very likely to assume the side curve $g'' h''$ too sharp; it would naturally be made a circular arc, and if intent on the appearance of that view only, we make the radius too small; the result, as shown, will be that in the side view the curve *g h* will be short and flat, which gives the appearance of a very abrupt change from the comparatively slender neck to the broad stub end.

It sometimes happens that in planning a machine, it is desirable, if not imperative, to employ a link with the gib and key, in a place where, if made as thus far shown, the key would in its motion interfere with some other piece. This difficulty can frequently be evaded by elongating the strap and the stub end, so as to remove the projecting key to a greater distance from the pin, as shown in Fig. 64. But under these circumstances the strap will be weakened by the elongation, not in regard to its tensile strength, but in regard to its side stiffness, so that it would be more liable to spring open under the oblique pressure, which almost invariably exists, because it seldom happens that both ends of the link move in right lines, one or the other usually, and very often both, traveling in circular arcs. This may be counteracted by putting a bolt through the strap from side to side, as in Fig. 46; the ordinary gib and key may be employed for taking up the lost motion, the bolt being introduced between the key and the butt end of the rod. Or, instead of this, a double gib may be used, which we have illustrated in Fig. 64, the key being driven between the two gibs, which latter thus grasp the strap in two places, and in this way prevent it from springing under the oblique pressure. Since in this case the reversed gib at the back of the key must bear against the stub end, it is to be noted that the heads or projections must be made much longer than those of the other, as the strap must of course be slotted out under them to a distance equal to the draft due to the assumed length of the key. This elongation would make the whole arrangement appear very heavy, if the stub end of the rod were to be left solid, for its entire length. This it is not necessary to do, as there is evidently much more metal than is required to do the work; we may therefore remove a part, which in the figure is done by making the elongated opening *c d* through the stub end from side to side. It might be objected that the amount of metal thus removed is not enough to pay for the trouble of doing it, and this we will not dispute. The mere intrinsic value of the material, however, is not the only thing to be considered. The weight of the link is lessened, which is a good thing in itself, so far as it goes, though the proportion of the actual reduction is not large enough to make that either go a great ways; but the *apparent* reduction is very considerable, as the reader may satisfy himself by finishing up the drawing first without this opening, and introducing it after he has studied the effect, when he will be astonished to see how much lighter and less clumsy it will look. It is, then, mainly to improve the appearance of the link that it is thus lightened. We know there are still some who say that such considerations are out of place in connection with machinery, and insist that if a device answers its end and does its work well, it is of no consequence how it looks; but we hope and believe that the number of such is becoming "small by degrees and beautifully less." For our own part, we can see no reason why elegance of design should not go hand in hand with correctness of proportion and excellence of workmanship. Be it understood that we are not advocating the introduction of ornamentation for its own sake, or the sacrificing of utility to beauty in any respect whatever. But we believe that there is such a thing as taste even in planning machinery, that the same end may be practically served equally well by two pieces, for instance, of which one may be undeniably ugly, while the other is pleasing to the cultivated eye. And we believe that the exercise of taste in this matter is an element of commercial success; that of two engines, for example, equally good in all respects, the better-looking one will find the readier and more extensive sale. We are are not speaking of the improved appearance due to better finish, but simply of that which may be secured by attention to such points as have been mentioned above; and in this conviction the reader has our reason for devoting to these and similar matters what may seem, to those who have not taken this view of the subject, unnecessary space. In Fig. 65 we give a drawing of a crank, or lever, which might be actuated by the link whose end is shown in the preceding figure. This is a very simple thing to draw, but, in spite of that, it is perfectly possible to draw it, and more particularly to figure it, in such a way as to give the workman some trouble in finding out just how to make it. Of course but two views are needed; and in the front or face view it will be noted that the pin is shown in section, which is because it is needless to give a front view of the collar on the outer end, and the arrangement selected enables us distinctly to indicate the taper of the conical part by the dotted circle. In this front view, it will also be observed that the breadth of the lever is

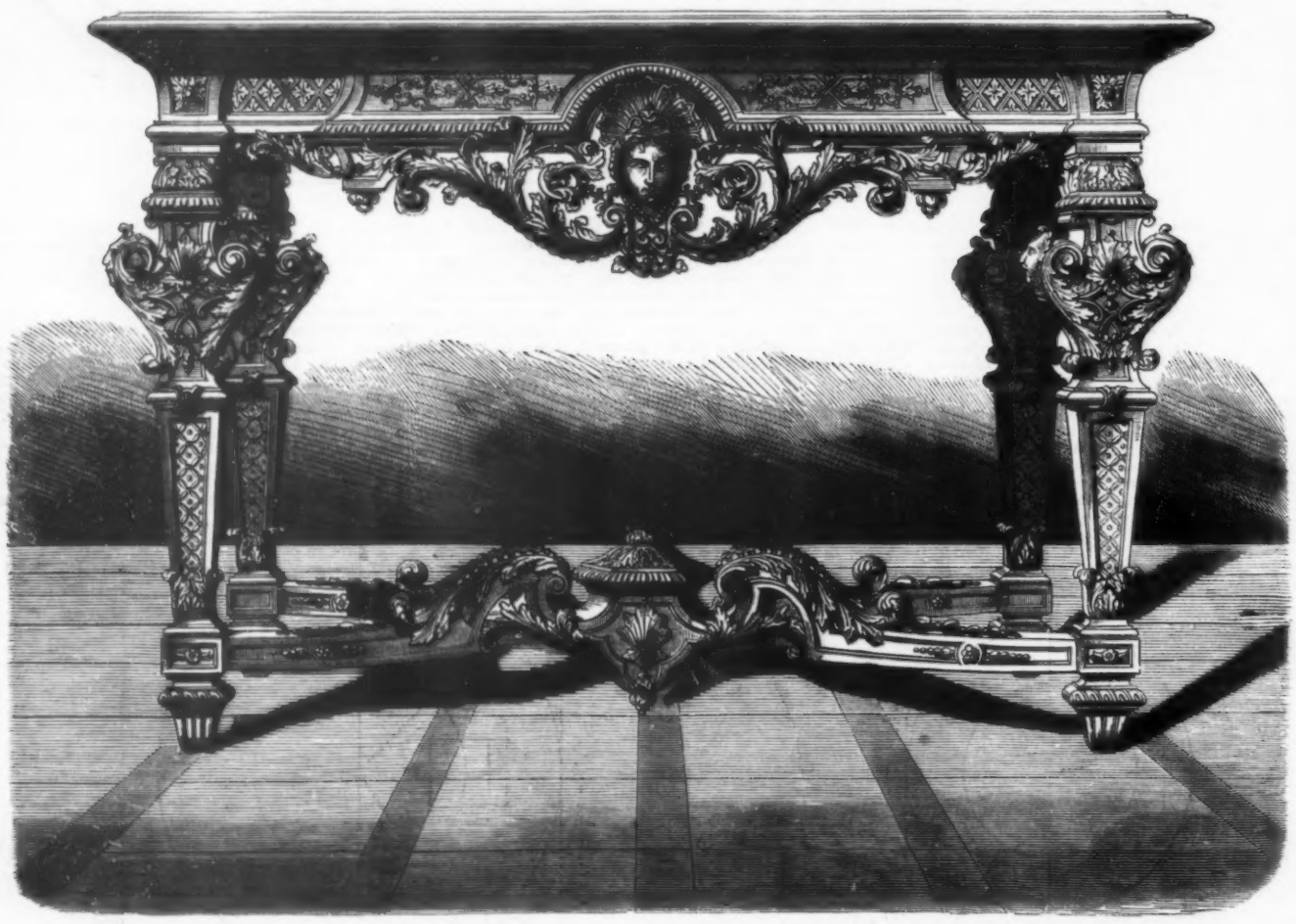

TABLE FROM BEREY CASTLE, NEAR PARIS. PERIOD OF LOUIS XIV.—(*From the Workshop.*)

evidently the form of this curve will affect that of the curve of intersection. They are, in short, mutually dependent upon each other, so that if we assume one of them we can construct the other. This is important, because it is very clear that the neatness and grace of the finish depends much more on the form of the curve of intersection, as seen in the side view, than it does upon the precise curvature of the side surface as seen in the top view. We therefore assume such a curve *g, k, h*, tangent to *c d*, as will form an easy and natural continuation of the latter. From this we now proceed to ascertain the curve which must be given to the side surface in order to produce this intersection. Since *g*, the point of tangency between *c d* and the assumed curve, (which must be assumed) is the last point of the former which is retained, it is clear that in the top view g'' will be the beginning of the curve, and the latter will be tangent to $y'' g''$, which represents the plane surface of the stub end; and h'' will be the point at which this curved surface will cut the entrance outline of the neck. Intermediate points are found as follows: If we draw in the side view any vertical line as *i o*, to the right of *d*, the point *i* will lie on the surface of the neck, and will therefore appear in the end view at i'; also i' o' will be the position of *i o* as seen in that end view, and in the top view the point i'' corresponding to *i* must be perpendicularly over the latter, and at a distance from the center line equal to *Oi'*. Similarly, *k p* appears in the end view as $k' p'$, and k'' is found over *k*, its distance from the center line being Op' in the end view. But when we go to the left of *d*, we have to take one more step in order to find a point. For instance, *m r* is a vertical element of our required surface; but we cannot find *m'* exactly as we did i'' and k', because the circle whose radius is Ch', on which those two points lie, represents the neck of the rod at its least diameter. But *m* clearly lies on the swell; to find *m'*, then, we continue *r m* to cut *a b* in *n*, which gives *r n* as marked in two places, by dotting dimension lines tangent to the hubs; the straight outlines being continued (in dotted lines) beyond the beginning of the curves by which they are joined to the hubs. This is for the purpose of giving the breadths at definite localities; frequently they are marked just at the points of tangency, which leaves the mechanic in doubt, as he has no positive clue to the mode of laying out the work, which he always ought to have. In the side view, attention is called to the fact that the center line of the link, *c d*, is drawn in, the center of the pin being marked by four radiating lines, thus, ✳ *which are not drawn through* the intersection of the center lines. This particular line is not needed by the workman in making the crank; but it is an important reference line in respect to putting the machine together, and ought always to be introduced, and the distances from it to the face of the lever and to the face of the hub ought to be marked, as well as the thickness of the lever and the lengths of the hubs. This matter will be again referred to when we come to consider the subject of planning, as the introduction of center lines of this sort will be found greatly to facilitate the comparison of drawings of different parts which are fitted to each other, as well as the making up of a general plan from the detached detail drawings.

The fact that the hubs are not turned with square corners at the junctions with the lever, but are provided with ample fillets, gives rise to well defined curves of intersection in the side view; another illustration of the constant recurrence of problems of this sort, which will be found so frequent as fully to warrant the space which has been devoted to them; the ones here shown should be readily constructed by the student without further aid than that given in the figure, when the method of finding one point is fully shown.